Draft Report

Total Maximum Daily Load For Dissolved Zinc And Cadmium In Silver Creek, Summit County, Utah

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February 5, 2004

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Silver Creek TMDL Executive Summary

(Relevant Section of TMDL Report in Parentheses)

I. Introduction

(See Section 1.0 for details)

Silver Creek Watershed - USGS Hydrologic Unit Code (HUC) #16020101

- Utah Waterbody ID # UT16020101-020 (see Figure 1)

- Located entirely within Summit County Utah

Listing & Priority: Silver Creek from the confluence with the Weber River to its headwaters is listed on Utah's 1998, 2000, and 2002 303(d) list of impaired water bodies. This waterbody is included in the "high priority" group on Utah's 303(d) list indicating a Total Maximum Daily Load (TMDL) should be completed at this time.

Water quality impairments: Zinc & Cadmium

Beneficial Uses Impaired: Class 3A – cold water species of game fish & aquatic life

II. Water Quality Standards

(See Section 2.0 for details)

R317-2-14 provides the numeric water quality standards for zinc and cadmium. Standards for zinc and cadmium are based on hardness. Pursuant to 303 (d) listing methodology now used by Utah, the **chronic water quality standards** are used for this TMDL. Using a hardness of 400 mg/l, the chronic water quality standards for zinc and cadmium are 0.39 mg/l and 0.00076 mg/l respectively.

III. Water Quality Standards Target

(See Sections 2.0 & 3.0 for details)

The hardness adjusted chronic water quality standards for zinc and cadmium will be used as the targets or endpoints for this TMDL.

Pollutant of Concern	Hardness Adjusted Chronic Water Quality Standard Target
Zinc	0.39 mg/l
Cadmium	0.00076 mg/l

IV. Significant Sources
(See Section 6.0 for details)

Historical evidence indicates the source of metals of concern in this watershed are from historical mining activities in the Park City area. Most of the mining activity occurred within the upper watershed, primarily within Empire Canyon. Tailings from these mines were stored onsite or removed to another location, typically downstream. Significant source areas for zinc and cadmium are identified on Figure 22 and summarized in the following table:

Description	Owner
Upper Watershed Sources	United Park City Mines
Prospector Square	Park City Municipal Corporation
Silver Maple Claims	BLM
Flood Plain Tails	United Park City Mines
Richardson Flats	United Park City Mines
Meadow Area	Various Private Land Owners

V. Technical Analysis
(See Section 7.0 for details)

Data are presented in Section 4.0 showing average concentrations and flows for bi-monthly periods at each “key” sampling location. Table 7 presents a summary of flows, concentrations and loads at key stations for each of these bi-monthly periods. Sections 9.0 and 10.0 provide the Best Management Practices (BMPs) that can be used to remedy the widespread nonpoint sources of metals in the Silver Creek Watershed. Literature values for the effectiveness of each BMP are provided in Table 14. Utilizing the removal efficiencies for each BMP, reductions in zinc and cadmium loading values are calculated along with anticipated stream concentrations after BMP implementation. Completion of scheduled BMPs is expected to achieve and maintain the TMDL endpoints for Silver Creek.

VI. Margin of Safety & Seasonality
(See Sections 4.0 & 5.0)

There is significant variability in the existing flow and chemical data set for this TMDL which lends uncertainty to the loading analysis. Additionally, there is uncertainty in the actual degree of success that implementation of the BMPs identified to address nonpoint sources will achieve. Accordingly, the Margin of Safety to address these sources of uncertainty for this TMDL will include the following components:

- An **explicit margin of safety of 25%** is utilized in the allocation calculations for the Silver Creek TMDL
- **Ongoing Monitoring** Program will be implemented
- Use of the maximum hardness of 400 mg/l in calculating the hardness adjusted Water Quality Standards that are used as the endpoint for this TMDL (use of actual hardness would have resulted in higher values for the Water Quality Standards)

Seasonal analysis of the data is described in section 4.0. Statistical analysis determined that bimonthly partitioning of the data best reflects the seasonal nature of the data.

VII. TMDL
(See Section 8.0 for details)

Table 12 provides the zinc and cadmium allocations for each key monitoring station in the Silver Creek Watershed. The reduction needed for each of the key stations varies from 48% to 86% for zinc and 31% to 92% for cadmium.

VIII. Allocation
(See Section 8.0 for details)

Section 8.0 and Table 12 include the allocation for zinc and cadmium between non-point sources, the one point source in the watershed and the margin of safety.

Waste Load Allocation calculations are included in Section 8.0 for the Silver Creek Water Reclamation Facility. Effluent limits for zinc (0.30 mg/l) and cadmium (0.00076 mg/l) are proposed to assure that the hardness adjusted chronic water quality standards used as endpoints for this TMDL are met in the stream after mixing with wastewater effluent. These effluent limits will not be required until significant progress is made on the non-point source pollution problems in the Silver Creek Watershed.

IX. Public Participation
(See Section 12.0 for details)

Section 12.0 provides the description of the rather extensive public involvement and participation for this TMDL. The Upper Silver Creek Watershed Stakeholders Group has held regular meetings since March 20, 2001. Several public meetings have been held to allow for public input and comment on this TMDL. A formal 30 day comment period was also provided for public comment on the draft TMDL.

Acronyms List

ac	Acre
AFY	Acre-feet per year
BLM	Bureau of Land Management
BMPs	Best Management Practices
$CaCO_3$	Calcium Carbonate
Cd	Cadmium
CF	Conversion Factor
cfs	Cubic Feet per Second
CV	Coefficient of Variation
DEQ	Department of Environmental Quality
DWQ	Division of Water Quality
EE/CA	Engineering Evaluation/Cost Analysis
HUC	Hydrologic Accounting Unit
in	Inches
LA	Load Allocation
lb	Pounds
lb/day	Pounds per Day
lb/mi	Pounds per Mile
mg/l	milligrams per liter
MOS	Margin of Safety
NPS	Non-Point Source
PIP	Project Implementation Plan
RAO	Response Action Objective
STORET	STOrage and RETrieval (water quality, biological, physical data)
TMDL	Total Maximum Daily Load
UPCM	United Park City Mines
UPDES	Utah Pollution Discharge Elimination System
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WLA	Waste Load Allocation
WRF	Water Reclamation Facility
Zn	Zinc

1.0 INTRODUCTION

1.1 Watershed Description

Silver Creek is a smaller tributary of the Weber River. The Weber River originates in Summit County near Reids Peak (11,708 ft) in the western end of the Uinta Mountain range and flows approximately 125 miles generally to the Northwest to the Great Salt Lake at approximately 4200 ft. elevation. Much of the watershed is included in the rugged Uinta and Wasatch Mountain ranges. The Ogden River, the major tributary to the Weber River, lies within Weber County and enters the Weber River approximately 12 miles upstream from its mouth. The other major tributaries to the Weber River are East Canyon Creek, Lost Creek, Chalk Creek, and Beaver Creek. Two smaller tributaries that can affect the water quality of the Weber River are Echo Creek and Silver Creek.

The Geology of the Watershed is complex and composed principally of sedimentary deposits. Mountainous portions of the watershed are comprised of more faulted and fractured rocks while lower portions of the drainage basin closer to the Great Salt Lake are alluvial and lacustrine deposits.

The Silver Creek watershed boundaries are defined by the USGS Hydrologic Accounting Unit (HUC) #16020101 and Utah Waterbody ID # UT16020101-020 (see Figure 1). The Silver Creek watershed is located entirely within Summit County.

Climate

Due to substantial differences in elevation within the watershed, precipitation patterns are markedly different throughout the watershed. Average annual precipitation ranges from 15 to 30 inches with the highest mountainous areas receiving the highest precipitation totals. As is the case with many western watersheds, annual precipitation totals vary dramatically. Snow accumulation and melt is a very significant feature in terms of the annual hydrologic cycle for this watershed.

Average maximum temperatures are in the mid eighties (highest in July) and average minimum temperatures are in the low teens (lowest in January).

Land Use

Land uses are quite varied throughout the watershed. High mountain areas are used for a variety of recreational and grazing purposes. There are several ski resorts and golf courses, as well as numerous agricultural land uses. Portions of the watershed are undergoing extensive growth from residential and commercial development. The agricultural uses are declining as the basin develops and becomes more urbanized.

Demographics

The population of Summit County was 32,236 in 2002. The county’s average annual rate of growth from 1990 to 2000 was 6.7%, the fastest rate of any county in Utah. Park City is the largest city in the county with a population of 7,371 (Census 2000). Median age is 33.3 years, average household size is 2.87 people per household, per capita income (the highest in the state

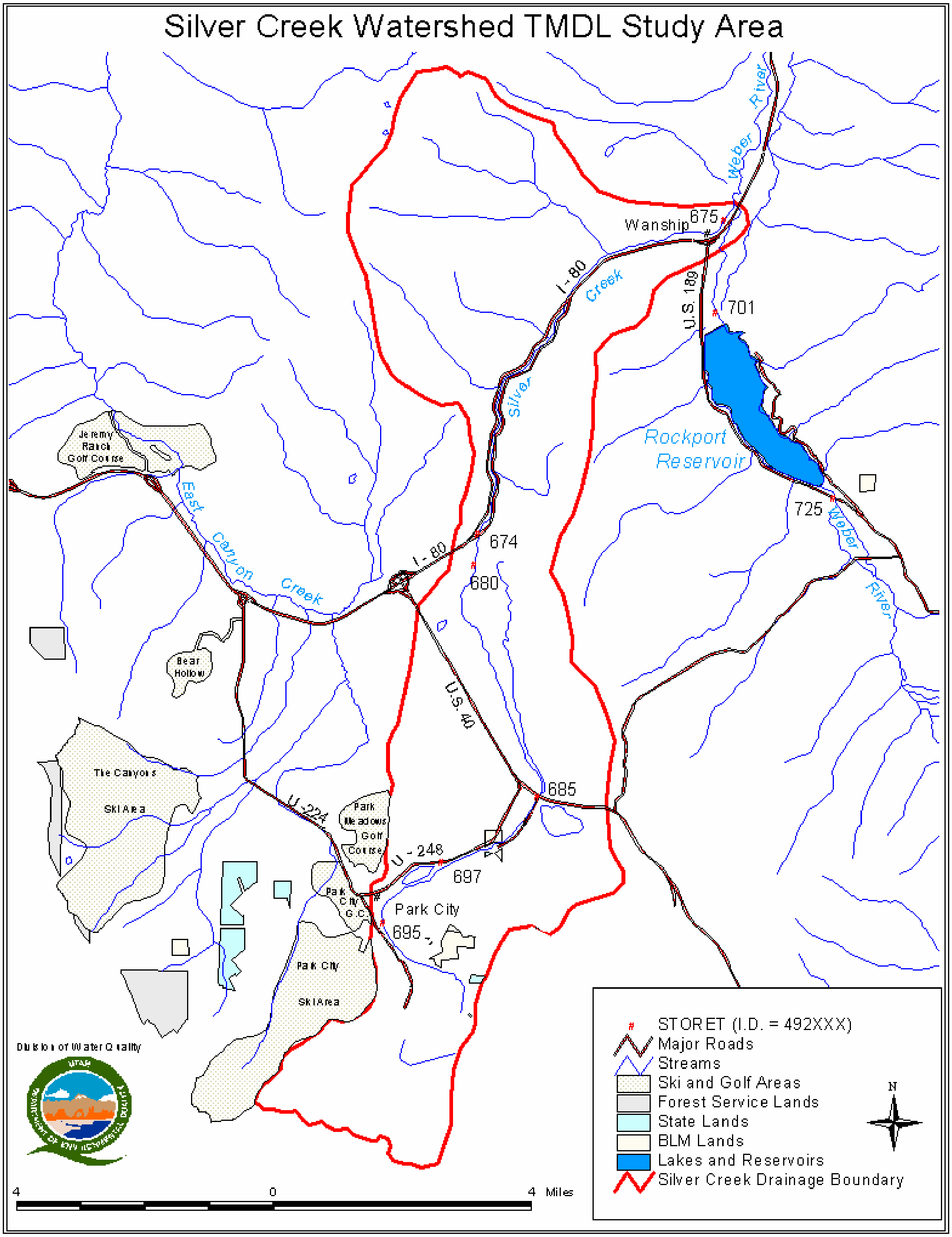

Figure 1: Silver Creek Watershed TMDL Study Area

of Utah) in 2001 was $42,102, unemployment rate in 2001 was 8.8%. Services and trade sectors accounted for nearly 56% of the county's nonagricultural employment – a figure consistent with the county's high specialization in tourism-related industries.

1.2 Water Budget

Hydrologic data are extremely limited and inconsistent within the Silver Creek watershed. These inadequacies make the preparation of a detailed water budget for the basin very difficult. As a result, this section presents the data that are available, and recognizes the need for additional monitoring of the watershed to better understand flows in streams, irrigation canals, and groundwater.

Weather Data

There are three weather stations in the vicinity of the Silver Creek watershed; located at Park City, Wanship Dam, and Silver Lake Brighton. Figure 2 shows the location of these stations.

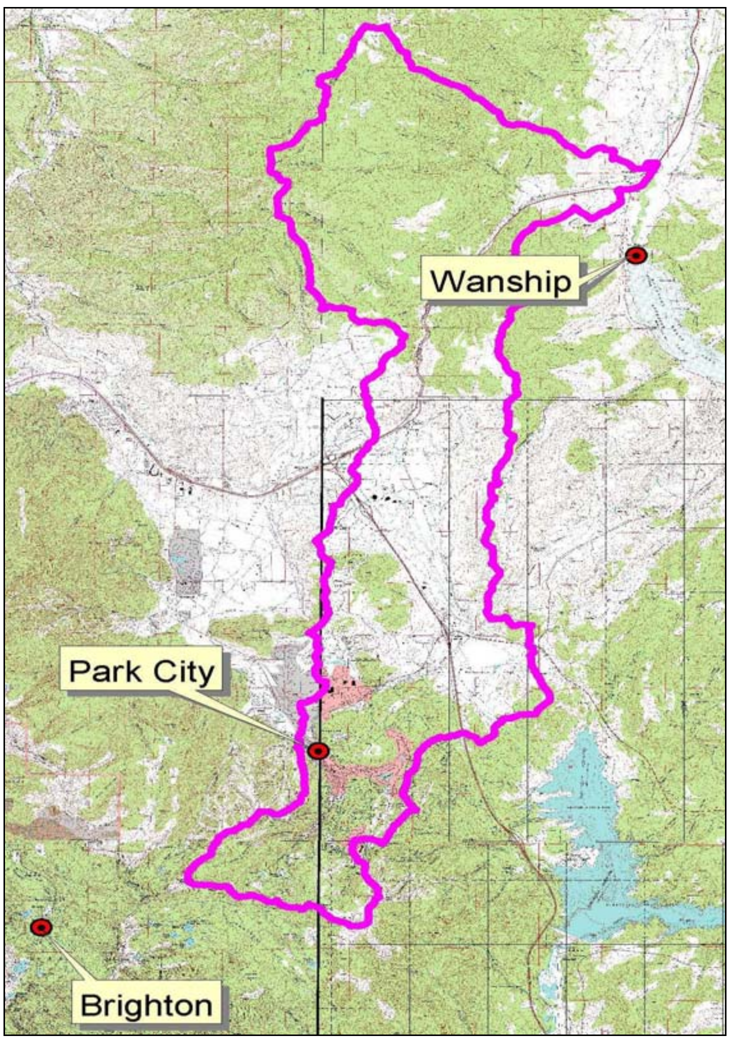

Figure 2: Weather Stations

Data for Normal Precipitation and Normal Potential Evapotranspiration were obtained for these three stations. Table 1 shows the area of influence for each of the weather stations, based on linear partitioning.

Table 1: Weather Station Areas of Influence

Station	Area (ac)	Percent of Watershed
Brighton	100	0.3%
Park City	13,778	45.4%
Wanship	16,443	54.2%
Total	**30,321**	**100 %**

Using these areas, monthly composite values for Normal Precipitation and Normal Potential Evapotranspiration were calculated. These values are shown in Table 2.

Table 2: Composite Watershed Weather Data

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total (in)	Total (AFY)
Total Precip (in)	1.56	1.25	1.52	1.63	1.63	1.13	1.66	1.33	1.91	1.45	1.78	1.71	18.55	47,000
Potential ET (in)	0.76	1.13	2.07	3.53	5.23	6.59	7.56	6.57	4.43	2.68	1.15	0.71	42.41	107,000

It is noteworthy to mention the relatively high value of Normal Annual Potential Evapotranspiration (shown in acre-feet per year), which is more than two times the Normal Annual Precipitation in the watershed. While this value does not represent true evaporation, it does reflect the dry climate of the watershed and the high potential for evaporation losses.

Flow Data

Flow data for each of the STORET sampling locations were typically recorded as water quality samples were taken. A hydrologic profile showing how average annual flow increases from the top of the watershed to the outlet is shown in Figure 3.

Figure 4 shows seasonal trends in flow for each of the key stations for each bimonthly period. Peak flows occur at Wanship in the second bimonthly period (March to April), while the other locations have their peak flow during the third bimonthly period (May to June).

The key stations included in the flow analysis and water quality analysis include:

Park City	492695
Richardson Flat	492685
Above Atkinson	492680
Silver Creek WRF	492679
Atkinson	492674
Wanship	492675

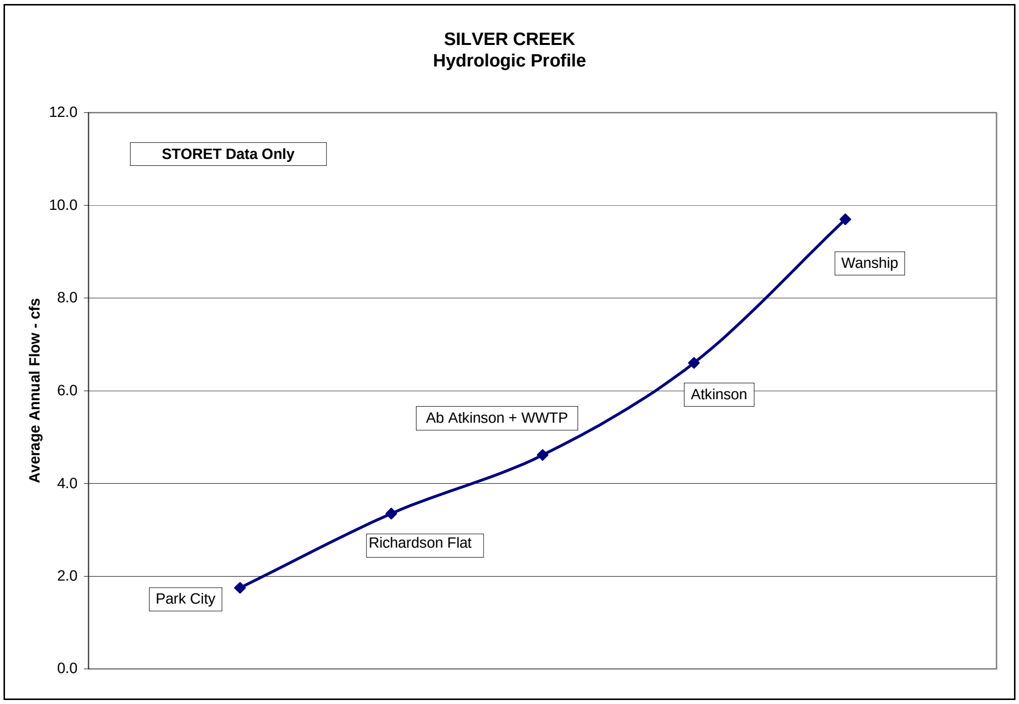

Figure 3: Silver Creek Hydrologic Profile

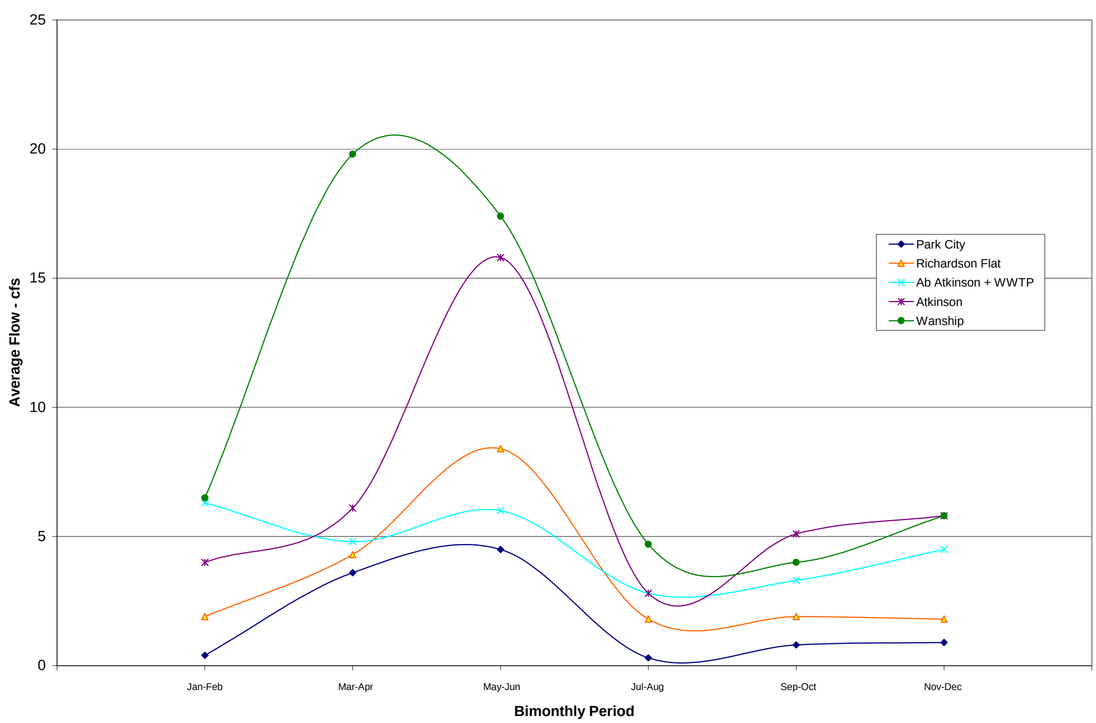

Figure 4: Silver Creek Annual Flow Patterns

Watershed Outlet

Flows at the Wanship sampling location (above the confluence with the Weber River) average 10 cfs. This corresponds to an average of approximately 7,000 acre-feet per year (AFY) leaving the watershed and entering the Weber River. Outflow from the watershed is approximately seven times less than the total amount of water coming into the watershed through precipitation, suggesting that the majority of the water exiting the system does so through mechanisms such as evapotranspiration, groundwater recharge etc.

Remaining Uncertainties

The following items remain unknown in this hydrologic system:

- Contribution of groundwater (inflow or outflow) to various stream reaches and/or trans-basin flow
- Watershed evaporation
- Locations and flows of irrigation diversions
- Effective precipitation

1.3 Water Quality Impairment

The Silver Creek from the confluence with the Weber River to its headwaters is listed on Utah's 1998, 2000, and 2002 303(d) list of impaired water bodies. This waterbody is included in the "high priority" group on Utah's 303(d) list indicating a Total Maximum Daily Load (TMDL) should be completed at this time.

Water quality concerns in the Silver Creek Watershed are focused on two metals; zinc and cadmium. Most indications suggest that the metals of concern in this watershed are from historical mining activities in the Park City area. Elevated concentrations of zinc and cadmium were the cause for Silver Creek being assessed as not fully supporting its Class 3A beneficial use.

2.0 WATER QUALITY STANDARDS

The Silver Creek watershed is listed on the State of Utah's 303(d) list as impaired for zinc and cadmium. Beneficial use 3A, protected for cold-water fish and other cold-water species, is identified as impaired. Water quality data and analysis are discussed in Sections 3 and 4. Data for the following constituents were gathered to quantify and evaluate this impairment:

- Total and Dissolved Cadmium
- Total and Dissolved Zinc
- Total Dissolved Solids
- Total Suspended Solids
- pH

Data for total dissolved solids and total suspended solids were gathered because metals such as zinc and cadmium are often present within these solids. Values for all of these constituents are sufficient to provide a good understanding of existing water quality impairments present in this area. Data for the constituents were gathered from the Utah Division of Water Quality (DWQ) and from the Environmental Protection Agency (EPA). Data beginning in January 1990 through 2002 were obtained for monitoring stations located on or near Silver Creek.

2.1 Water Quality Targets and Endpoints

Water quality standards for zinc and cadmium were obtained from the State of Utah, Rule R317-2-14. This rule states that the standards for zinc and cadmium are dependent on the hardness of the water. Hardness is used as a surrogate for a number of water quality characteristics which affect the toxicity of metals. Increasing hardness has the effect of decreasing the toxicity of metals. Water quality criteria to protect aquatic life may be calculated at different concentrations of hardness measured in milligrams per liter (mg/l) as calcium carbonate ($CaCO_3$). (EPA, National Recommended Water Quality Criteria 2002, www.epa.gov/waterscience/pc/revcom.pdf.)

Table 3 shows the equations provided by the State of Utah to calculate these standards.

Table 3: Water Quality Standard Calculations

	Chronic
Zinc	CFx $e^{(0.8473(\ln(hardness))+0.884)}$
Cadmium	CFx $e^{(0.7409(\ln(hardness))-4.719)}$

The average hardness measured in the Silver Creek watershed was found to be 484 mg/l. The equations shown in Table 3 are only considered valid up to a hardness of 400 mg/l. Therefore, a hardness of 400 mg/l was used for the purpose of establishing the water quality standards for zinc and cadmium. Because the calculated water quality standard increases as hardness increases, using this lower value for hardness results in a more conservative (stricter) standard. Table 4 shows the resulting water quality endpoints which were used in this analysis.

Table 4: Water Quality Endpoints For Silver Creek

Constituent	Chronic (mg/l)
Zinc	0.39
Cadmium	0.00076

*Based on hardness of 400 mg/l $CaCO_3$

The chronic Water Quality Standard is used in the Silver Creek TMDL based on Utah's recent adoption of chronic criteria for listing waters in the 303(d) process (March 27, 2003 letter from Don Ostler, to Bruce Zander, EPA Region 8).

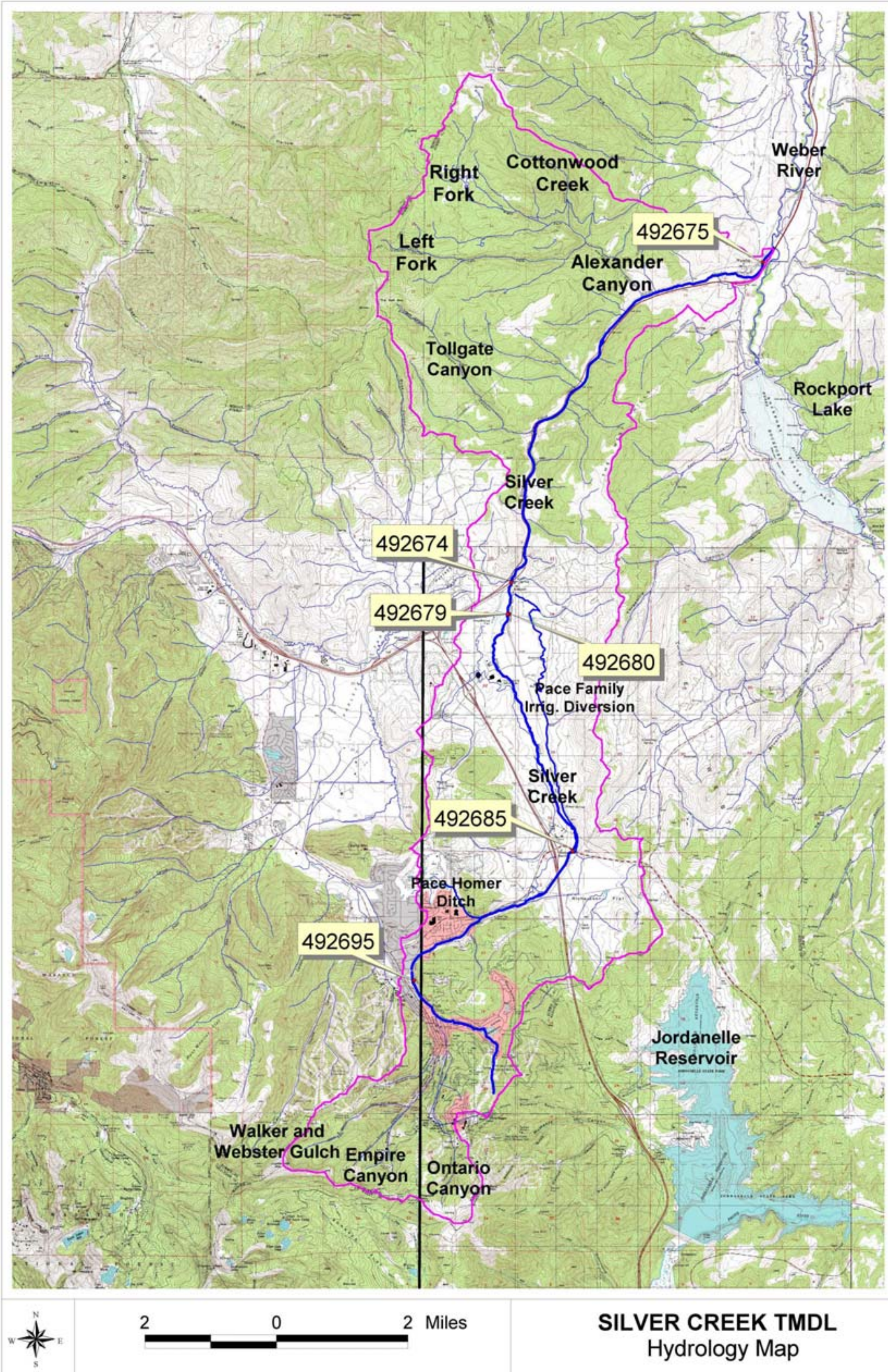

Figure 5: Silver Creek Hydrology Map

3.0 WATER QUALITY DATA

3.1 Sources of Data

In order to assess the quality of the water in Silver Creek and to quantify the impairment of the stream with respect to zinc and cadmium, several sources of data were considered. These data sources were collected by different government agencies and are summarized below and in Appendix A of this report.

STORET

STOrage and RETrieval (STORET) is a repository for water quality, biological, and physical data, and it is used by state environmental agencies, EPA and other Federal agencies, universities, private citizens, and many others. This data was collected by the Utah Division of Water Quality over a twelve-year period between 1990 and 2002, and covers the reach of Silver Creek from the Weber River at Wanship upstream to a station located near Bonanza Drive in Park City (see Figure 5). Not all of the sampling stations were sampled consistently throughout this period.

USGS

USGS conducted two separate studies on Silver Creek, one in 2000 and another in 2002. The USGS sampling locations cover the same reach of the stream as do the STORET stations.

USEPA

In the Year 2000, USEPA sampled during the Spring, Summer, and Autumn periods in the reach of the stream from the vicinity of Richardson Flats upstream to the headwaters of Silver Creek.

3.2 Data Limitations

As with many studies of this nature, there has been unsystematic sampling conducted throughout the watershed. The sampling has included different time spans, non-uniform sampling within the time spans, and inconsistent flow measurements. Sometimes flow measurements were made concurrently with water quality sampling, and at other times no flow measurements were made. There do not appear to be any data points where only flow measurements were made.

Figure 6 shows the sampling performed for dissolved zinc at the STORET locations. Only two sampling locations have data for the entire time span of the study. Most locations have data limited to small time periods.

Generally there are small populations of data for most time periods. This necessitated the clustering of the individual data points. The purpose of the clustering was to be able to compute statistically reliable parameters for each time interval within the year. Because the standard error of estimate of the mean value for populations is approximately proportional to the inverse of the square root of the number of data points, it is important to have a minimum number of data points in order to reasonably estimate the mean value for the population. Therefore, the time interval for clustering was expanded until such time as the minimum number of data points per interval was in the range of 4 to 5. In order to accomplish this objective, it was necessary to cluster the data into two-month intervals. That is to say, the data within each two-month period was considered to be of the same population. Therefore, for characterizing Silver Creek water quality, both water quality data and flow data were clustered into six two-month intervals for the purpose of calculating mean values, and from these values determining annual patterns.

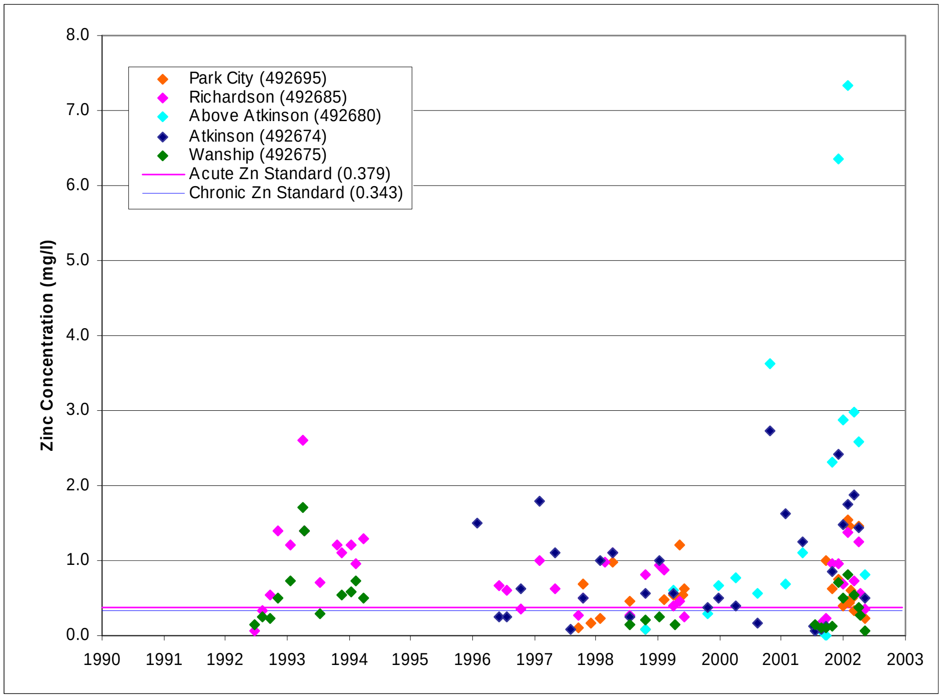

Figure 6: STORET Zinc Data Scatter Plot

Because of the inconsistency of flow and water quality sampling data, flow and concentration data were separated. Independent estimates of means for each data set were then calculated. Estimates of loadings were then calculated using the mean values for flow and concentration for each bi-monthly cluster.

3.3 Key Sampling Locations

Because of the longer time period embodied in the STORET data (11 years), the focus was on this data set. This data set was used for the principal analysis in this study. The USGS and USEPA data were overlaid and used for verification. There are nine STORET stations on Silver Creek in the reach between Park City and the confluence with the Weber River. There are no STORET stations above Park City. Of these nine STORET locations, five are selected as “key”. In addition to these, the Silver Creek Water Reclamation Facility was included, because of it’s potential as being a source of pollutant loadings. Table 5 shows these stations, their period of record, and the reasons why some were not used.

Table 5: Key STORET Locations

STORET	Description	Key Station	Period of Record	Comments
492674	Silver Creek In Atkinson	Yes	1996-2002	
492675	Silver Creek In Wanship Ab. Weber R.	Yes	1992-2002	
492676	Silver Creek 2 Miles North of Atkinson	No	Prior to 1990	Not Sampled 1990-2002
492677	Silver Ck at I-80	No	Prior to 1990	Not Sampled 1990-2002
492679	Silver Creek WWTP	No	1998-2002	Not on Silver Creek
492680	Silver Creek Ab. Atkinson	Yes	1998-2002	
492685	Silver Creek Below Richardson Flats	Yes	1992-2002	
492695	Silver Creek Ab. Prospector Square	Yes	1997-2002	
492697	Park Meadow Drain Ck. Ab. Silver Creek	No	1998-1999	Not on Silver Creek

The USGS and USEPA sampling stations used for this report are summarized in Table 6. The original study station designations as well as nearby STORET locations (in parentheses in each header) are presented.

Table 6: USGS, EPA Sampling Locations and Corresponding STORET Sites

Above Atkinson (492680)		
USGS	2002	SCS-6000 Silver Creek Above Silver Creek WWTP
Atkinson (492674)		
USGS	2000	Silver Creek At Atkinson
USGS	2002	SCS-6500 Silver Creek At Atkinson (Below WWTP)
Park City (492695)		
USEPA	2000	USC-8, State Sample Site
USGS	2000	Silver Creek At Bonanza Dr.
Richardson (492685)		
USEPA	2000	USC-1, Rail Tressel @ U248
USEPA	2000	USC-2, Culvert @ U248
USEPA	2000	USC-3, Upstream RR Tressel
USGS	2000	Silver Creek Above Richardson Flats
USGS	2002	SCS-5500 Silver Creek Below Richardson Flats - USGS 2002
Wanship (492675)		
USGS	2000	Silver Creek At Wanship
USGS	2002	SCS-7000 Silver Creek @ Wanship

4.0 DATA ANALYSIS RESULTS

4.1 Zinc and Cadmium Standards

Water quality standards for zinc and cadmium are discussed in Section 2.0. A review of the data shows 57% (131 of 230) of the zinc values included in the data set (Appendix A) exceed the hardness adjusted water quality standard of 0.39 mg/l. Similarly, 52% (117 of 226) of the cadmium values observed exceed the hardness adjusted water quality standard of .00076mg/l.

4.2 Water Quality and Flow Results by Location

The water quality analysis in Section 4.2 does not depict the revised water quality standards adopted by Utah on Jan. 6, 2004. TMDL endpoints and targets in other sections have been modified to incorporate the new water quality standards.

This section presents average concentrations and flows for each of the "key" sampling locations during each of the six bi-monthly periods. A summary of findings is provided followed by three figures showing bi-monthly zinc concentrations, bi-monthly cadmium concentrations, and bi-monthly flow.

Park City

Zinc concentrations are lowest during the fourth period (July, August) and the highest during the first period (January, February). Water quality standards for zinc are exceeded during the first half of the year. Concentrations reach 1.5 times the standard. Flows are relatively low, and are greatest during the second and third periods (March through June).

Cadmium concentrations are lowest in the fourth and fifth periods (July through October) and highest in the second period (March through April). Concentrations exceed the chronic standard during the first half of the year. No exceedences of the acute standard were found.

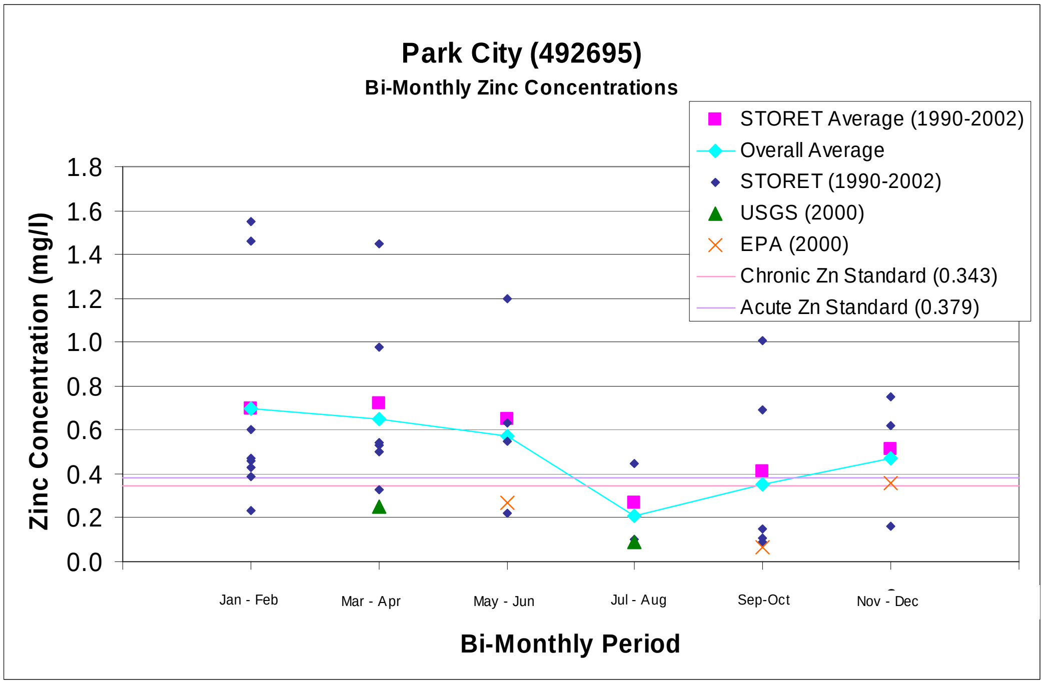

Figure 7: Park City Bi-Monthly Zinc

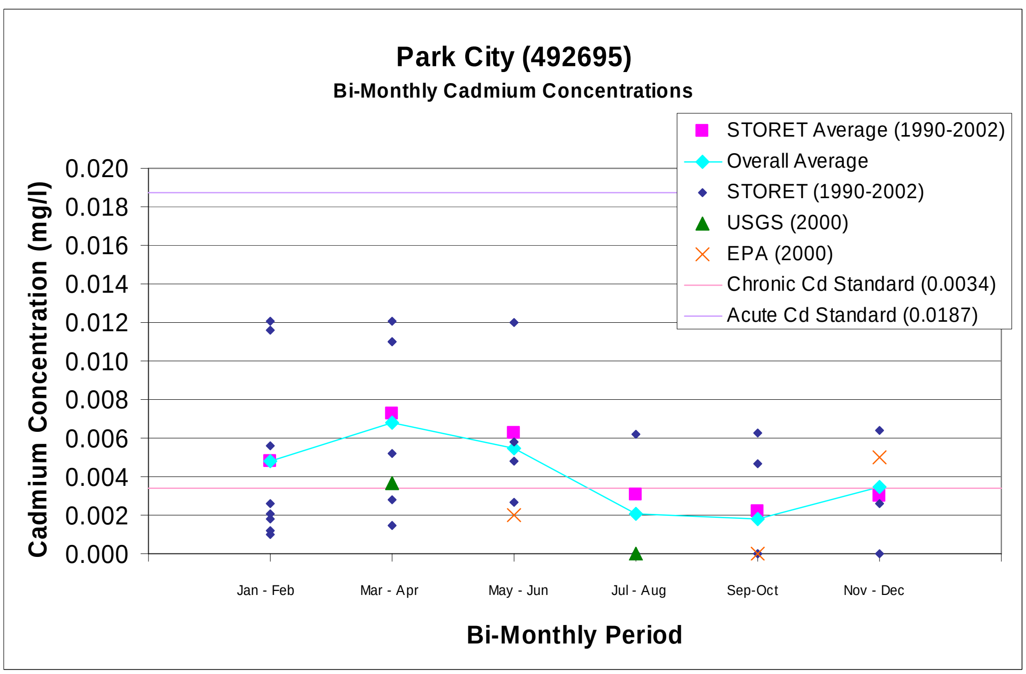

Figure 8: Park City Bi-Monthly Cadmium

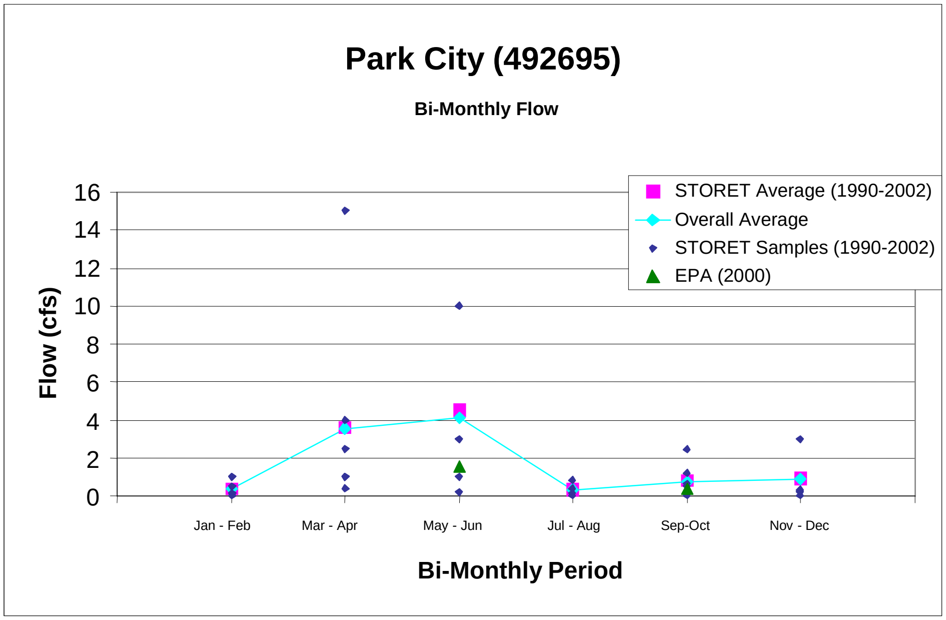

Figure 9: Park City Bi-Monthly Flow

Richardson

Zinc concentrations were found to be highest during the Winter and early Spring (Nov. through April) and lowest during the Summer and Fall months. On average, water quality standards for zinc are exceeded throughout the year, with concentrations reaching two times the standard. Flows peak in the third and fourth periods (from March to June).

Cadmium concentrations are highest in the second period (March through April). No violations of the chronic or acute water quality standards are typical.

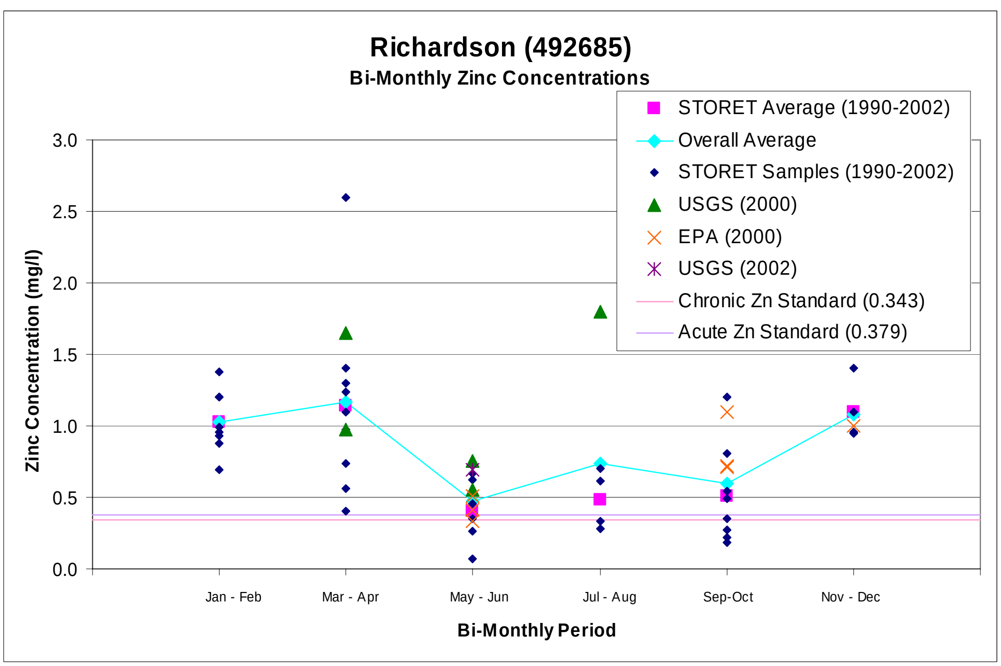

Figure 10: Richardson Bi-Monthly Zinc

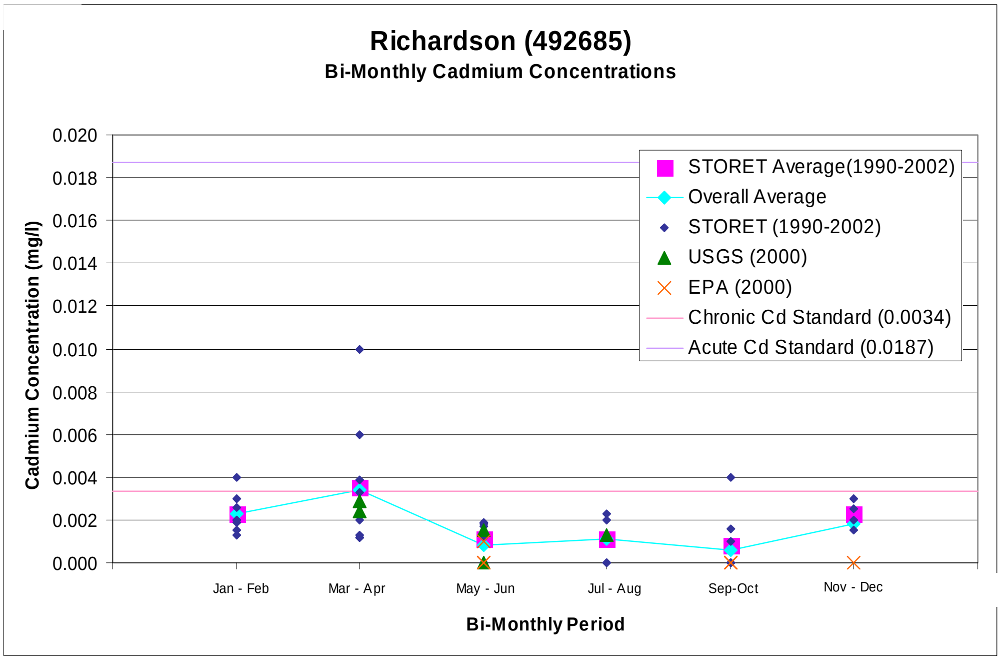

Figure 11: Richardson Bi-Monthly Cadmium

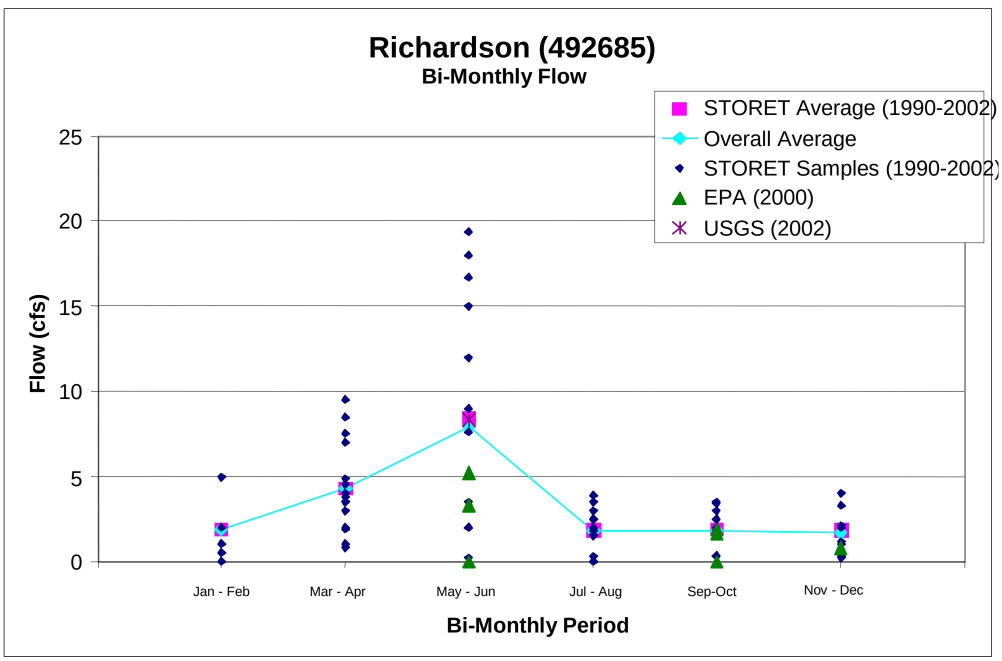

Figure 12: Richardson Bi-Monthly Flow

Above Atkinson

Zinc concentrations are highest during the Winter months (Nov. through Feb.) and lowest during late Summer and Fall (Sept. through Oct.). Water quality standards for zinc are exceeded for most of the year. Zinc concentrations reach up to six times the standard. Flow fluctuates during the year with the highest flows during late Winter and early Summer. During the irrigation season, a significant flow is typically diverted into the Pace Family Irrigation Diversion. This diversion takes water from Silver Creek just below Richardson Flat and returns between the Atkinson and Above Atkinson water quality sampling stations.

Cadmium concentrations are the highest during the Winter months (November through February). Late Summer and early Autumn months (July through October) have never had values above the detection limit. Chronic water quality standards are typically exceeded during the rest of the year. Exceedences of acute water quality standards were not found.

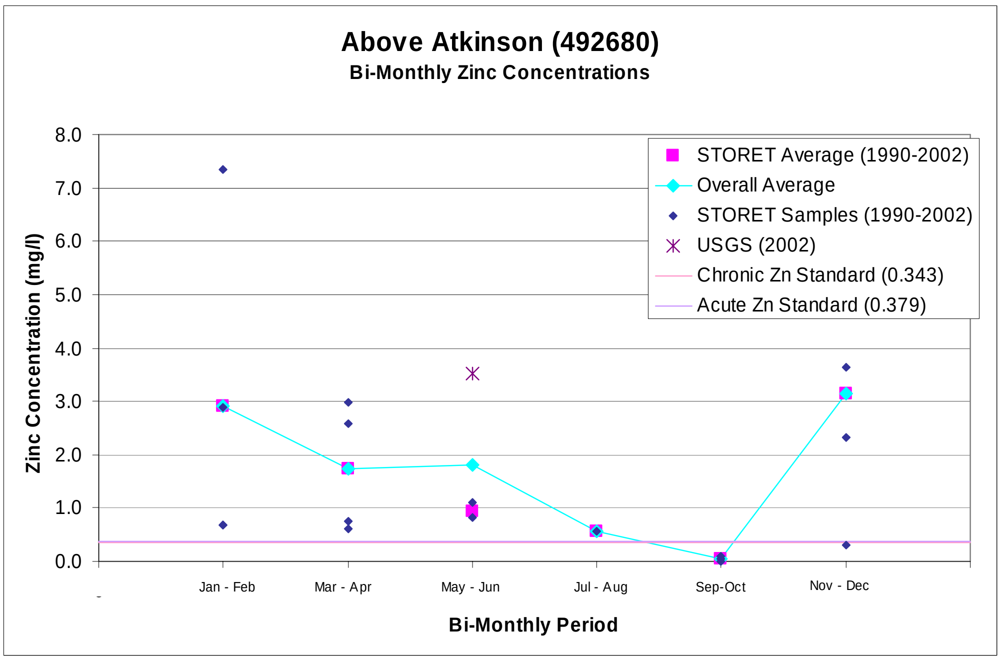

Figure 13: Above Atkinson Bi-Monthly Zinc

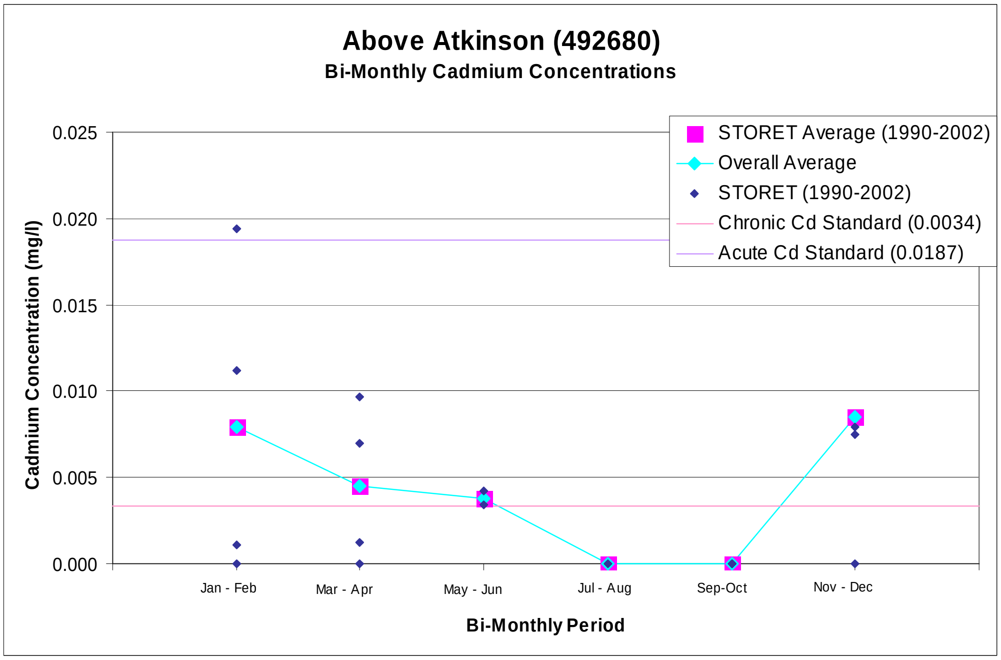

Figure 14: Above Atkinson Bi-Monthly Cadmium

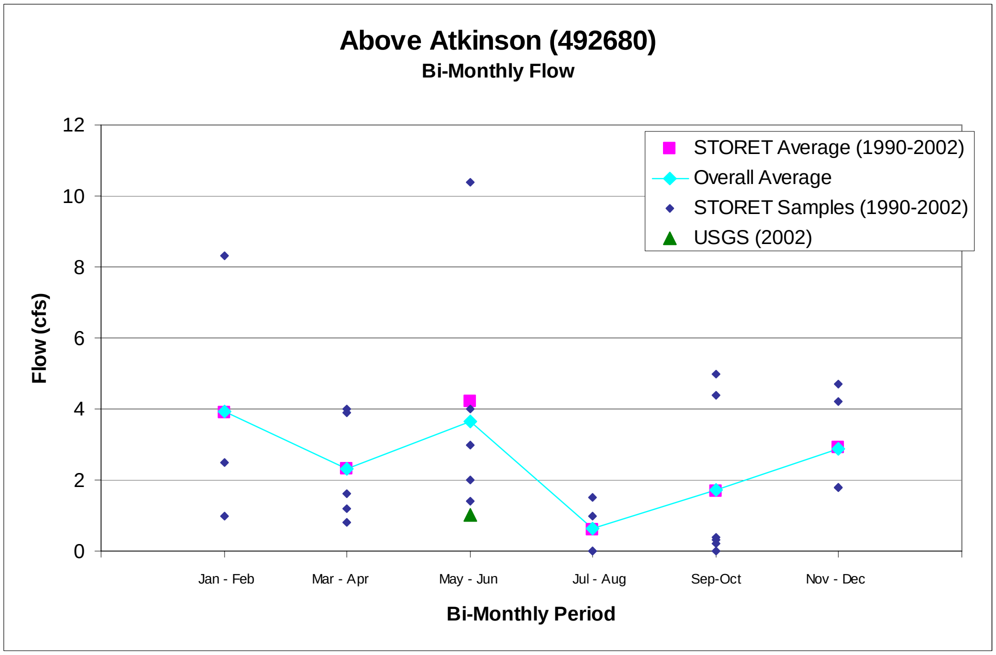

Figure 15: Above Atkinson Bi-Monthly Flow

Atkinson

Zinc concentrations are highest during the Winter months (November through February) and lowest during the late Summer months (July and August). Water quality standards for zinc are typically exceeded from November through June. Average zinc concentration reach three times the zinc standard. Flows are the highest during the months of May and June.

Cadmium concentrations are lowest during the late Summer and early Autumn. Average concentrations are always below acute and chronic water quality standards.

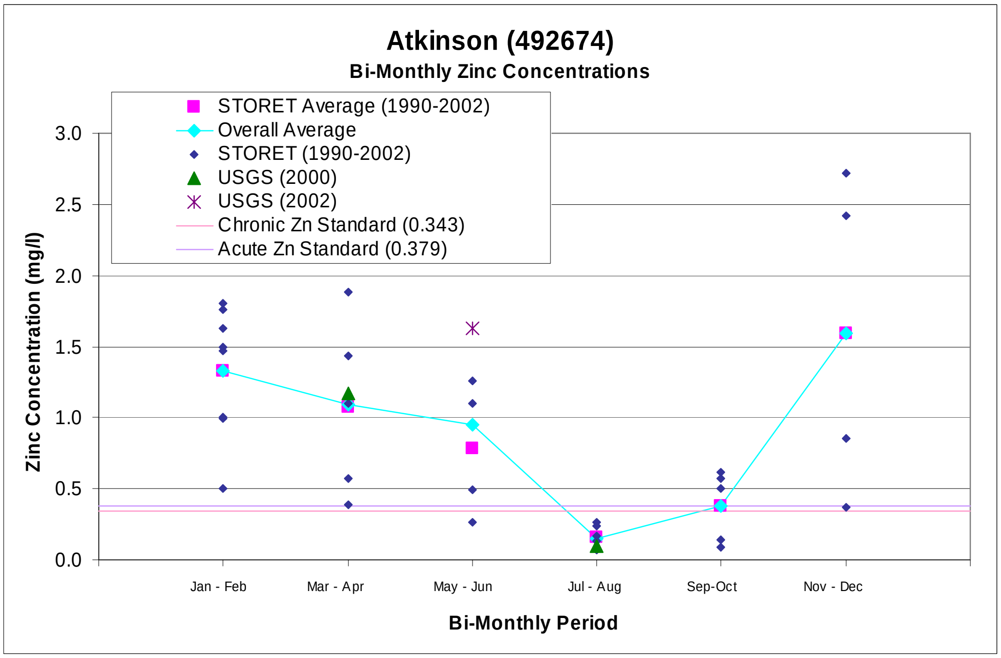

Figure 16: Atkinson Bi-Monthly Zinc

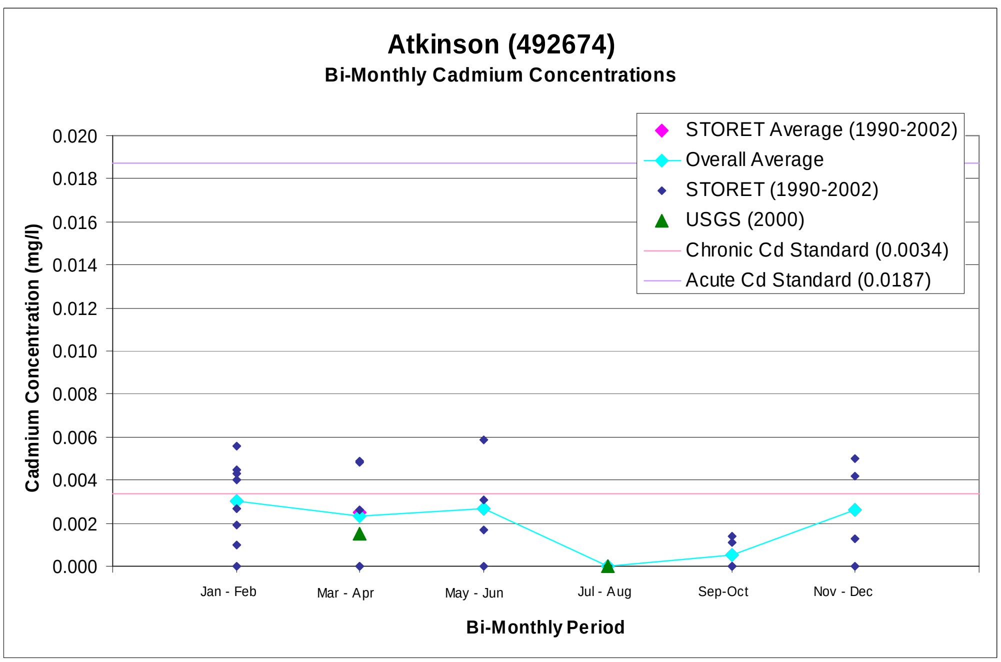

Figure 17: Atkinson Bi-Monthly Cadmium

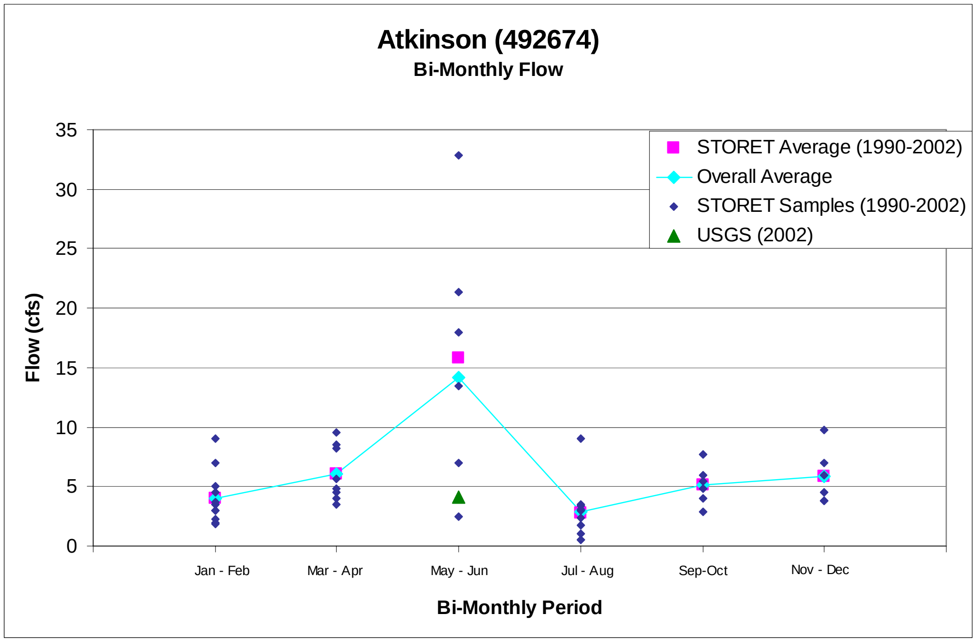

Figure 18: Atkinson Bi-Monthly Flow

Wanship

Zinc concentrations are highest during the Winter and Spring months (Nov. – April). Flows are highest during the Spring and early Summer months (May and June).

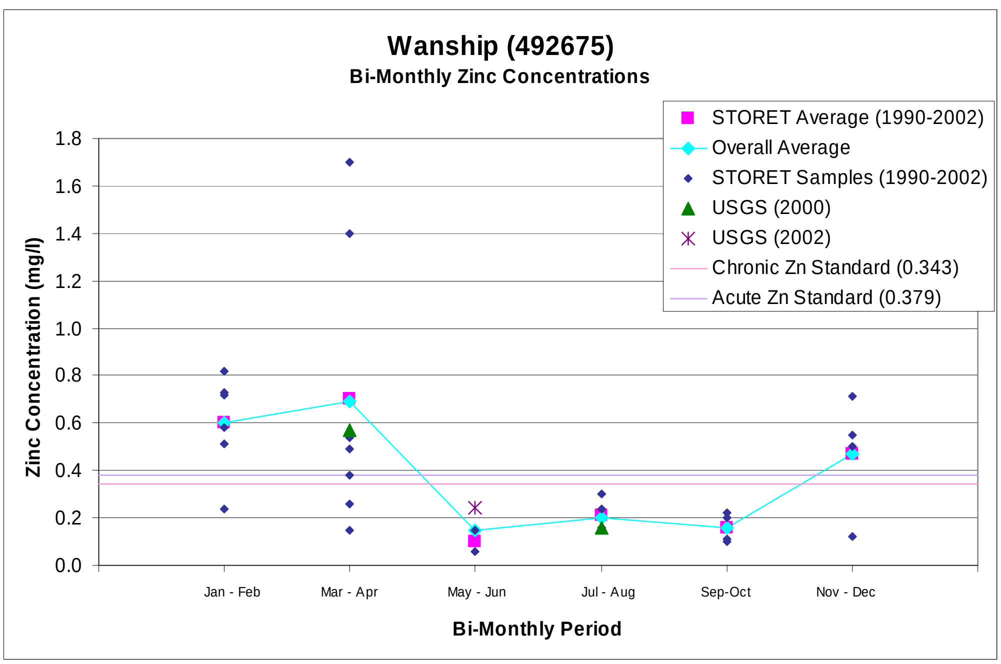

Figure 19: Wanship Bi-Monthly Zinc

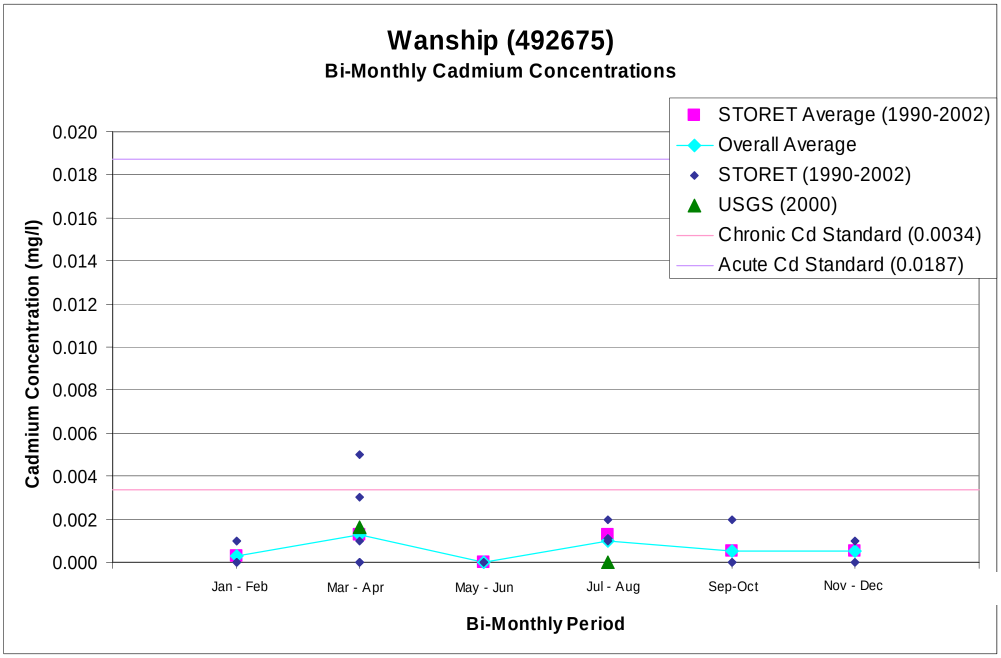

Figure 20: Wanship Bi-Monthly Cadmium

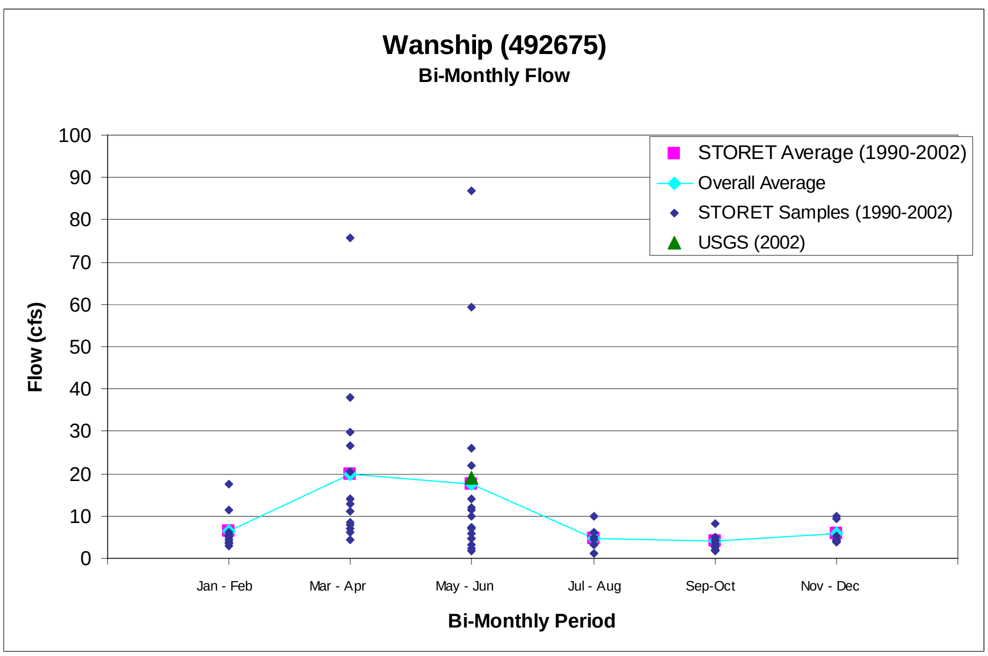

Figure 21: Wanship Bi-Monthly Flow

4.3 Hardness

Seasonal analysis of hardness data for each of the five key sampling locations indicates that there is significant variation by season at all stations except 492685 (Richardson Flat). Appendix C includes graphical representation of the seasonal variation by station. While the sufficiency of the data set does not allow a concise conclusion, there appears to by a general pattern that involves lower hardness values during spring runoff (March-July) than during more base flow conditions (August –February). This seasonal variation results in two stations (492695 – Park City and 492675 – Wanship) that demonstrate hardness values that are significantly below the hardness value of 400 used to calculate TMDL target values. Sections 8.1 and 8.2 include a discussion of how TMDL target levels were modified to accommodate seasonal variation for these two stations in order to assure stream water quality standards are maintained throughout the year at these two stations.

4.4 Zinc and Cadmium Loading

Table 7 summarizes the zinc and cadmium loading for the reach of Silver Creek between Park City and the confluence with the Weber River. Values for each bi-monthly period for each of the five key stations are shown. The average flows for each period along with the average dissolved zinc and cadmium concentrations for the period are used to compute average daily loads shown in the table. Another column, showing the load, presents totals for each bi-monthly period. Summing these bi-monthly numbers results in an annual load. The annual load for each station has been rounded to the nearest 1,000 pounds per year for zinc and to the nearest one pound per year for cadmium. This rounding is consistent with the statistical parameters developed for flow and concentration.

Table 7: Summary of Flows, Concentrations, and Loads by Key Station

Period	Average Flow (cfs)	Average Dissolved Zinc (mg/l)	Average Dissolved Zinc Load (lb/day)	Dissolved Zinc Load (lb)	Average Dissolved Cadmiuim (mg/l)	Average Dissolved Cadmium Load (lb/day)	Dissolved Cadmium Load (lb)
Park City (492695)							
Jan-Feb	0.4	**0.70**	1.4	85	**0.0048**	0.01	0.6
Mar-Apr	3.6	**0.65**	12.4	759	**0.0068**	0.13	7.9
May-Jun	4.1	**0.57**	12.6	771	**0.0055**	0.12	7.4
Jul-Aug	0.3	0.21	0.4	23	0.0021	0.00	0.2
Sep-Oct	0.7	**0.35**	1.4	85	0.0018	0.01	0.4
Nov-Dec	0.9	**0.47**	2.2	136	**0.0035**	0.02	1.0
			Annual Load:	**2,000***			**18****
Richardson (492685)							
Jan-Feb	1.9	**1.03**	10.4	616	0.0023	0.02	1.4
Mar-Apr	4.3	**1.17**	27.1	1,655	0.0034	0.08	4.8
May-Jun	7.9	**0.47**	20.0	1,220	0.0008	0.03	2.1
Jul-Aug	1.9	**0.74**	7.4	458	0.0011	0.01	0.7
Sep-Oct	1.9	**0.60**	6.0	365	0.0006	0.01	0.4
Nov-Dec	1.7	**1.08**	9.7	590	0.0018	0.02	1.0
			Annual Load:	**5,000***			**10****
Above Atkinson (492680)							
Jan-Feb	3.9	**2.90**	61.5	3,627	**0.0079**	0.17	9.9
Mar-Apr	2.3	**1.73**	21.6	1,321	**0.0045**	0.06	3.4
May-Jun	3.6	**1.81**	35.5	2,168	**0.0038**	0.07	4.5
Jul-Aug	0.6	**0.57**	1.9	118	0.0000	0.00	0.0
Sep-Oct	1.7	0.05	0.5	28	0.0000	0.00	0.0
Nov-Dec	2.9	**3.15**	48.6	2,964	**0.0085**	0.13	8.0
			Annual Load:	**10,000***			**26****
Silver Creek WWTP (492679)							
Jan-Dec	2.4	0.14	1.8	700	0.0000	0.00	0.0
			Annual Load:	**700**			
Atkinson (492674)							
Jan-Feb	4.0	**1.33**	28.8	1,701	0.0030	0.07	3.8
Mar-Apr	6.1	**1.09**	35.7	2,180	0.0023	0.08	4.6
May-Jun	14.2	**0.95**	72.7	4,432	0.0027	0.21	12.6
Jul-Aug	2.8	0.15	2.3	142	0.0000	0.00	0.0
Sep-Oct	5.1	**0.38**	10.5	641	0.0005	0.01	0.8
Nov-Dec	5.8	**1.59**	49.9	3,045	0.0026	0.08	5.0
			Annual Load:	**12,000***			**27****
Wanship (492675)							
Jan-Feb	6.5	**0.60**	20.9	1,235	0.0003	0.01	0.6
Mar-Apr	19.8	**0.69**	73.5	4,486	0.0013	0.14	8.4
May-Jun	17.5	0.15	14.2	864	0.0000	0.00	0.0
Jul-Aug	4.7	0.20	5.1	317	0.0010	0.03	1.6
Sep-Oct	4.0	0.16	3.4	209	0.0005	0.01	0.7
Nov-Dec	5.8	**0.47**	14.8	903	0.0005	0.02	1.0
			Annual Load:	**8,000***			**12****

*** Rounded to the nearest 1,000 lbs per year**
**** Rounded to the nearest 1 lb per year**
Red Bold Type indicates Exceedence of Chronic Water Quality Standard

Table 8 presents the coefficients of variation for flow, zinc concentration, and cadmium concentration at each of these key locations.

Table 8: Coefficients of Variation

Location	Dissolved Zinc	Dissolved Cadmium	Flow
Park City	77%	93%	182%
Richardson	58%	108%	112%
Ab. Atkinson	108%	125%	99%
Silver Ck. WRF	50%	n/a	39%
Atkinson	80%	113%	95%
Wanship	87%	152%	137%

The coefficient of variation is determined as the standard deviation of the population divided by its mean value. This is a measure of how tightly the data are clustered around the mean value. Lower numbers indicate that most of the data points are located close to the mean, while higher numbers indicated a wider spread of data points. The Above Atkinson and Silver Creek WRF sampling stations have the highest and lowest coefficients of variation, respectively, for zinc concentration. Thus, more confidence may be placed in the mean zinc value at the WRF than in the mean value at the Above Atkinson Station.

The only Point Source in the watershed is the Silver Creek Water Reclamation Facility. Average annual loads for this facility are also shown in Table 7. The average zinc concentration and average flow for the water reclamation facility are 0.14 mg/l and 2.2 cfs, respectively. These levels result in an estimated average loading of 1.8 pounds per day or 598 pounds per year. There are no recorded samples in the data where cadmium is above the detection limit. This results in a calculated cadmium load of zero pounds per year.

Table 9 shows the incremental loading between each of the five key stations. Also shown are the estimated distances, in miles, between each of the key stations as well as the incremental loading rate in pounds per year per mile of stream.

Table 9: Incremental Loading Results

Location	Dist. (mi) -	Incremental Zinc Load (lb)	Zinc Load Rate (lb/mi)	Incremental Cadmium Load (lb)	Cadmium Load Rate (lb/mi)
Park City	2.6	2,000	770	18	6.9
Richardson	3.4	3,000	900	-8	-2.4
Ab. Atkinson	4.1	5,000	1,200	16	3.9
Atkinson	0.5	2,000	4,000	1	2.0
Wanship	7.5	-4,000	-500	-15	-2.0

For zinc, it is of interest to note that between Park City and Richardson the annual loading rate is only 900 pounds per year per mile of stream. Between Richardson and Above Atkinson the loading rate is in the same range, 1,200 pounds per year per mile. Between the two Atkinson stations (0.5 miles) the annual incremental load amounts to 2,000 pounds for a loading rate of approximately 4,000 pounds per year per mile of stream. Between Atkinson and Wanship, the zinc loading actually decreases by 4,000 pounds per year. This decrease is likely associated with precipitation/sedimentation of zinc and incorporation of those materials into the sediments of that reach. This results in a loading rate of -500 pounds per year per mile of stream.

For Cadmium, there is a loss of load between Park City and Richardson. Between Richardson and the Above Atkinson location, there is a gain of 16 pounds per year. A minor increase in load occurs progressing towards the Atkinson location. Similar to zinc, there is a significant loss of cadmium load in the reach between Atkinson and Wanship, likely due to sedimentation.

4.4 Water Quality Overview

Zinc

An analysis of Table 7 (page 28) leads to three important conclusions concerning Silver Creek zinc concentrations:

- Zinc concentrations tend to be the highest during periods of late Winter and Spring runoff.
- Elevated concentrations of zinc occur throughout the reaches of Silver Creek between Park City and Wanship.
- The highest concentrations of zinc were found at Above Atkinson, where bi-monthly averages were over five times the chronic water quality standard for four of the six bimonthly periods.

Calculated loadings by stream reach point to potential remediation priorities. The largest load increments are in the reaches between Richardson and Atkinson; they amount to 7,000 pounds per year. Next in priority would be between Park City and Richardson with incremental load amounts of about 3,000 pounds per year.

Lastly, annual load at Park City is about 2,000 pounds. However, careful consideration must also be given to the sequence of clean up from an upstream to downstream order to insure that upstream sources do not contaminate areas downstream that have been addressed earlier. This issue will be covered in detail in Section 10.0, Project Implementation Plan.

Between Park City and Richardson, the incremental load amounts to about 3,000 pounds per year. Therefore, the focus of attention as far as remediation should be in the reach of Silver Creek between Park City and Atkinson.

Continued improvement in the upper watershed associated with active mine reclamation and resort development will likely continue to reduce the exposure of surface waters to mining impacted areas and should reduce metal concentrations in this portion of the watershed. Areas in the watershed that are currently being developed include the upper watershed area and the East side of the meadow area (Figure 22). It is expected that all future development activities will avoid contaminated areas and, as a result, it is expected that these areas will not contribute zinc or cadmium load to Silver Creek.

The reach of Silver Creek between Atkinson and Wanship shows a decrease of approximately one-third in zinc loadings. This is probably associated with precipitation/sedimentation, which suggests that the zinc is still present and could be mobilized by high flow events or a change in water chemistry. However, the historic data set that encompasses more than 10 years does not indicate that accumulated metals are being released in disproportionate quantities. Assuming that clean-up and remediation take place in the upper and central portion of the watershed, additional remediation in the lowest reach of the stream would be a last priority, undertaken if this reach appears problematic following watershed work upstream.

Cadmium

Some 52% of the cadmium observations exceeded the chronic water quality standard. Clean up priorities for cadmium based on loading analysis should be targeted at the stream reach above and between Richardson and Atkinson.

5.0 MARGIN OF SAFETY

5.1 Assumptions

All data for the analysis in this TMDL study was provided by the Utah Department of Environmental Quality (DEQ), Division of Water Quality (DWQ). DWQ adheres to the *DEQ DWQ Quality Assurance Quality Control Manual* to ensure proper sampling and data validation from sampling through analysis. All samples are analyzed by Department of Health Division of Laboratory Services (a.k.a. State Health Lab) which is EPA certified on its procedures. Quality assurance procedures (i.e. blank and duplicate samples) are strictly adhered to and enforced.

Seasonal trends and data scatter are such that it would be virtually impossible to demonstrate statistically valid long term trending. Therefore, it was assumed that there were no significant long term trends in the data.

5.2 Margin of Safety

A discussion of the statistical methods used to analyze the Silver Creek water quality and flow data is included in Appendix C. As pointed out in this appendix, although the statistical analysis resulted in satisfactory results, there remain significant uncertainties in the estimates of representative concentrations and loadings based on the variability of the existing data. In recognition of this uncertainty the Margin of Safety for this TMDL will include the following components:

- An explicit margin of safety of 25% is utilized in the allocation calculations for the Silver Creek TMDL.
- Ongoing Monitoring Program will be implemented.
- Use of the maximum hardness of 400 in calculating the hardness adjusted Water Quality Standards that are used as the endpoint for this TMDL (use of actual hardness would have resulted in a higher values for the Water Quality Standards).

6.0 SOURCES

6.1 Known Sources of Contaminants

Existing data were adequate for determining contaminant loading between data sampling points along Silver Creek (contaminant loading is presented in pounds per mile of stream rather than by responsible parties in Section 4.3). However, sufficient data are unavailable to adequately allocate contribution of contaminants by specific site. Table 10 identifies the major land owners within the various source areas of Silver Creek. Figure 22 identifies the major contaminated areas, which are referred to as source areas.

Table 10 : List of Known Sources

Description	Owner
Upper Watershed Sources	United Park City Mines
Prospector Square groundwater drain	Park City Municipal Corporation
Silver Maple Claims	BLM
Flood Plain Tailings	United Park City Mines
Richardson Flats	United Park City Mines
Meadow Area	Various Private Land Owners

Most indications suggest that the metals of concern in this watershed are from historical mining activities in the Park City area. Most of the mining activity occurred within the upper watershed, primarily within Empire Canyon. Tailings from these mines were stored onsite or removed to another location, typically downstream.

Several downstream locations were used to further reduce and process the discarded mine tailings in an attempt to remove additional materials. The lower reaches of the stream have significant amounts of mine tailings that are easily detected by the casual observer. These locations include, but are not limited to, Silver Maple Claims, Richardson Flats, Flood Plain Tailings and the Meadow area.

Contamination mechanisms vary from site to site but are generally attributed to surface or ground water contact with mining related metals contamination. The upper watershed, due to its overall steepness, is characterized by relatively high flow velocities and concentrations that have a tendency to carry sediments and other materials to receiving waters, in this case Silver Creek and its tributaries. Contaminated areas that are exposed or saturated by shallow ground water will contribute to metals loading in the stream channels.

The Upper watershed source area includes discharges from two mining tunnels, the Judge and Spiro Tunnels. The majority of these flows are captured for use in the Park City Municipal drinking water system. Zinc concentrations for these tunnels have been reported at 0.81 mg/l for the Judge and 0.22 mg/l for the Spiro Tunnel (NPDES Form 2A October 2002). Estimated zinc loads from the respective tunnel flows that actually enter Silver Creek are less than 100 lbs. per year from the Judge Tunnel and 300 lbs. per year from the Spiro Tunnel. These values are not significant when contrasted with the upper watershed zinc loads that are estimated at 2000 lbs. per year.

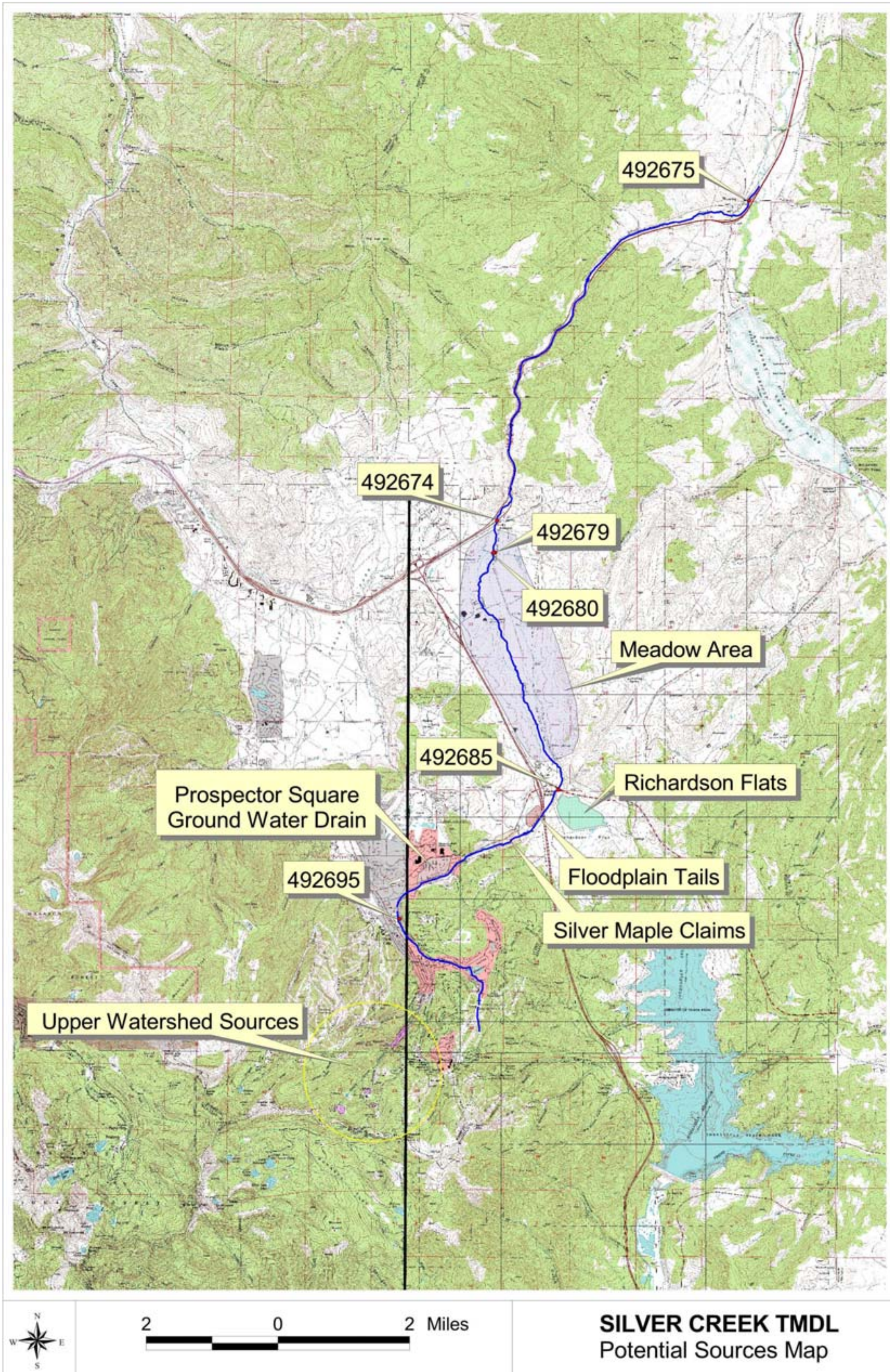
492675
492674
492679
492680
Meadow Area
492685
Richardson Flats
Prospector Square
Ground Water Drain
492695
Floodplain Tails
Silver Maple Claims
Upper Watershed Sources
2
0
2 Miles
SILVER CREEK TMDL
Potential Sources Map

Figure 22: Silver Creek Contaminant Source Map

As the terrain flattens, flow velocities in the stream and from runoff events decrease and begin to deposit the sediments from the upper watershed. Increased sediment deposition leads to increased contamination at these locations (Park City, Silver Maple Claims, Meadow area).

The middle to lower reaches (Flood Plain, Richardson Flats, Meadow area) are substantially flatter than the upstream reaches. These areas were used for tailing reprocessing and disposal. The landscape is littered with mounds of contaminated mine tailings. The meadow area from just below Richardson Flat to Atkinson is nearly completely covered with tailings. The stream channel runs through tailings for a stretch of approximately 4 miles in this meadow area. The contamination processes that are visually apparent include direct storm water runoff to the creek, direct stream contact with tailings and shallow ground water contact with tailings. The ground water table is fairly high and is believed to exchange freely with water in Silver Creek, thus increasing the contaminant load in the stream.

The Silver Creek WRF is a relatively small source of zinc loading currently as it contributes approximately only 598 of the 12,000 lbs per year of zinc passing the Atkinson Station (See Table 7). This represents 5 percent of the total load at Atkinson. Additionally, none of the samples for zinc obtained at the WRF in the 12-year period of this study exceeded the water quality standard for zinc. However, once best management practices are implemented in Silver Creek, the relative contribution of the WRF will become more significant. If growth projections for the WRF are met, the discharge volume will grow from a current value of 1.4 MGD to 2.0 MGD in the next 10 years. This would result in the WRF contributing some 628 lbs. of zinc annually to a combined load at Atkinson after BMP implementation of 4,810 lbs. (13% of the combined load)

Cadmium levels have consistently been below the detection limit, indicating that the WRF does not appear to be a contributor of cadmium to Silver Creek.

The last stream reach (to Wanship) has no tailings or other sources of contaminants besides sediment loads within the stream. This reach is the only section of stream that exhibits reducing levels of contaminants, again probably due to contaminants being adsorbed or precipitated.

Table 11: Source Information

Stream Reach	Source(s)	Owner(s)	Supporting Studies
Above Park City	Upper Watershed	United Park City Mines	Empire Canyon Innovative Assessment Report, DEQ, DERR, 2001 Empire Canyon Draft EECA, United Park City Mines, 2003 USGS WRI 03-4296, 2003; (Silver Maple Claims Loading Study) Data Interpretation Report Upper Silver Creek Watershed, EPA, 2001
Park City to Richardson Flat	Prospector Square Silver Maple Claims Flood Plain Tails Richardson Flat	Park City Municipal BLM United Park City Mines United Park City Mines	Richard Flat RI/FS, United Park City Mines, 2003 USGS WRI 03-4296, 2003; (Silver Maple Claims Loading Study) Data Interpretation Report Upper Silver Creek Watershed, EPA, 2001
Richardson Flat to Wanship	Meadow Area	Various Private Land Owners	Lower Silver Creek Innovative Assessment, DEQ, DERR, 2002 USGS WRI 03-4296, 2003; (Silver Maple Claims Loading Study) Data Interpretation Report Upper Silver Creek Watershed, EPA, 2001

6.2 Future sources

United Park City Mines is actively reclaiming mining related disturbed areas in preparation for development construction planned for the upper watershed. Continued improvement in the upper watershed associated with resort development will likely continue to reduce the exposure of metal contaminated materials and should reduce metal concentrations in this portion of the watershed. Areas in the watershed which are currently being developed include the upper watershed area and the East side of the meadow area. It is expected that all future development activities will avoid contaminated areas and, as a result, it is expected that these areas will not contribute zinc or cadmium load to Silver Creek.

7.0 TECHNICAL ANALYSIS

Establishing a relationship between the in-stream water quality targets and source loading is a critical component of the TMDL development. Identifying the cause and effect relationship between pollutant loads and the water quality response is necessary to evaluate the loading capacity of the receiving water bodies. The loading capacity is the amount of pollutant that can be assimilated by the water body while still attaining and maintaining water quality standards. This section discusses the existing and estimated loadings for zinc and cadmium in the Silver Creek watershed.

7.1 Estimation of Existing Load

Estimation of existing loads for zinc and cadmium were calculated using monitoring stations as described in Section 3.3 (Tables 5 & 6). STOrage and RETrieval (STORET) data was collected by the Utah Division of Water Quality over a twelve-year period between 1990 and 2002, and covers the reach of Silver Creek from the Weber River at Wanship upstream to a station located near Bonanza Drive in Park City. Not all of the sampling stations were sampled consistently throughout this period. USGS conducted two separate studies on Silver Creek, one in 2000 and another in 2002. The USGS sampling locations cover the same reach of the stream as do the STORET stations. In the Year 2000, USEPA sampled during the Spring, Summer, and Autumn periods in the reach of the stream from the vicinity of Richardson Flats upstream to the headwaters of Silver Creek.

7.2 Comparison of Existing Load and Loading Capacity

A water hardness of 400 mg/l was used for establishing the water quality standards for zinc and cadmium. Target annual loads were calculated using hardness adjusted water quality standards. For zinc, the resulting water quality endpoint is 0.39 mg/l. For cadmium, the resulting water quality endpoint is 0.00076 mg/l.

Data are presented in Section 4.0 in the form of average concentrations and flows for bi-monthly periods at each “key” sampling location. Table 7 presents a summary of average flows, concentrations and loads at key stations for each of these bi-monthly periods. This presentation allows for a seasonal analysis of the data for this TMDL. It is apparent that the period from November through February generally is the most critical from a metals concentration perspective with concentrations at their peak during this four month period. This pattern is evident in virtually all of the key stations analyzed. Accordingly, this four month period will be considered the most critical in achieving and maintaining water quality standards for Silver Creek.

In order to achieve the reductions desired, a list of Best Management Practices (BMPs) was developed for the cleanup and/or isolation of mining contaminated materials from stream flows. BMPs are discussed in Section 9.0. Removal efficiencies and costs for BMPs are discussed in Section 10.0. Utilizing the removal efficiencies for each BMP, reductions in zinc and cadmium loading values are calculated along with anticipated stream concentrations after BMP implementation. Completion of scheduled BMPs is expected to achieve and maintain the TMDL endpoints for Silver Creek. Ongoing monitoring as BMPs are implemented will allow verification of progress made toward meeting the endpoints identified for this TMDL.

8.0 TMDL

The purpose of the TMDL report is to provide an estimate of the acceptable load or the degree to which the current pollutants need to be decreased to attain the defined endpoints. This process is based on the following equation:

$$TMDL = \sum WLAs + \sum LAs + MOS$$

Where:

- WLA = Waste Load Allocation (for point sources – Water Reclamation Facility)
- LA = Load Allocation (for non-point sources) = (target concentration) x (average flow)
- MOS = Margin of Safety = 25%

Table 12 summarizes the TMDL data for both zinc and cadmium. Data presented is in the form of annual load reduction needed and percent reduction required to attain the TMDL endpoints.

Table 12: Zinc and Cadmium Load Allocations / Reductions

Zinc								
Location	Current Avg. Flow (cfs)	Current Annual Load (lbs/yr) [1]	TMDL Target Annual Load (lbs/yr) [2]	Annual NPS Load Allocation (lbs/yr)	Waste Load Allocation (lbs/yr) [3]	Margin Of Safety (lbs/yr) [4]	Overall Annual Reduction Needed (lbs/yr)	% Annual Reduction
Park City	1.7	1,859	870 [5]	652	0	217	989	65%
Richardson	3.2	4,905	2,443	1,832	0	611	2,462	63%
Above Atkinson	2.5	10,226	1,909	1,432	0	477	8,317	86%
Atkinson	6.3	12,142	4,810	1,778	1,830	1203	7,332	70%
Wanship	9.7	8,014	5,535 [5]	2,322	1,830	1384	2,479	48%

1. Current Load = sum of Bimonthly loads in Table 7
2. Using zinc concentration of 0.39 mg/l
3. WLA for Silver Creek WWTP includes 2 MGD @ 0.30 mg/l
4. Margin of Safety is 25%
5. Target loads were adjusted at Park City and Wanship to accommodate seasonally lower hardness levels during spring runoff

Cadmium								
Location	Current Avg. Flow cfs	Current Annual Load (lbs/yr) [1]	TMDL Target Annual Load (lbs/yr) [2]	Annual NPS Load Allocation (lbs/yr)	Waste Load Allocation (lbs/yr) [3]	Margin Of Safety (lbs/yr) [4]	Overall Annual Reduction Needed (lbs/yr)	% Annual Reduction
Park City	1.7	17.6	1.8 [5]	1.3	0.0	0.4	15.8	92%
Richardson	3.2	10.3	4.8	3.6	0.0	1.2	5.5	65%
Above Atkinson	2.5	25.8	3.7	2.8	0.0	0.9	22.1	89%
Atkinson	6.3	26.8	9.4	2.4	4.6	2.4	17.4	74%
Wanship	9.7	12.3	11.3 [5]	3.8	4.6	2.8	1.0	31%

1. Current Load = sum of Bimonthly loads in Table 7
2. Using cadmium concentration of 0.00076 mg/l
3. WLA for Silver Creek WWTP includes 2 MGD @ 0.00076 mg/l
4. Margin of Safety is 25%
5. Target loads were adjusted at Park City and Wanship to accommodate seasonally lower hardness levels during spring runoff

8.1 Zinc

All of the stations indicate TMDL reductions for zinc are required. The greatest reduction (86%) is needed in the stream reach between Richardson and Above Atkinson (Meadow Area on Figure 22). However, all stream reaches except between Atkinson and Wanship require reductions of 63% or greater.

Two key stations (492695 – Park City and 492675 – Wanship) demonstrated seasonal variation in hardness values, principally during the March through June time period, that were significantly below the 400 hardness standard used for calculating TMDL targets (see Appendix B for details). Accordingly, the zinc TMDL target for these two stations was lowered sufficiently to be protective.

8.2 Cadmium

TMDL reductions are required for Cadmium at all stations based on the newly adopted water quality standard. The greatest reduction (92%) is needed above the Park City station (492695). All stream reaches except between Atkinson and Wanship need load reductions of 65% or greater.

The cadmium TMDL target for the Park City and Wanship stations were adjusted downward in similar fashion to the zinc values to accommodate for seasonally lower hardness values as explained in section 8.1

8.3 Silver Creek Water Reclamation Facility

The Silver Creek WRF is a relatively small source of zinc loading currently contributing approximately only 598 of the 12,000 lbs per year of zinc passing the Atkinson Station (See Table 7). This represents 5 percent of the total load at Atkinson. Additionally, none of the samples for zinc obtained at the WRF in the 12-year period of this study exceed the chronic water quality standard for zinc. If growth projections for the WRF are met, the discharge volume will grow from a current value of 1.4 MGD to 2.0 MGD in the next 10 years with an ultimate buildout at 4.3 MGD. The source of zinc in the Silver Creek WRF effluent is from the drinking water supply for Park City. As growth continues in the Snyderville Basin area, new sources of drinking water will not have the background zinc concentrations currently evident in the drinking water supply. Existing sources are at maximum production and will not contribute any added water to the drinking water supply. New water sources will most probably come from waters not impacted by historic mining.

Projected zinc concentrations and annual loads from the WRF using estimated average zinc effluent concentrations, assuming new sources of drinking water have little if any metals, are shown in table 13.

The flows from the Silver Creek WRF provide significant dilution of zinc concentrations in Silver Creek. As the plant effluent flows grow and zinc concentrations are reduced, via increased inflows from source waters without measurable zinc values, this dilution impact will increase. The WRF provides a positive impact on water quality in Silver Creek in regards to metal concentrations.

Table 13. Growth Projections; Silver Creek WRF

Silver Creek WRF			
	WRF Flows (MGD)	Zn (mg/l)	Load (lbs./yr.)
Current 2003	1.4	0.14	598
Est. by 2010	2	0.103	628
Max Build-out	4.3	0.054	708

A flow weighted mixing model was utilized to derive the required effluent limits for the Silver Creek WRF for zinc. The following inputs and assumptions were included in this analysis:

- A realistic growth component was incorporated into the analysis by utilizing the WRF's growth projections. The current flow average for the plant of 1.4 MGD is expected to grow to 2.0 MGD over the next 10 years.
- The historical effluent concentration of zinc and cadmium from the WRF of 0.14 mg/l and below detection level respectively, will be reduced given that new sources of drinking water will come from sources not contributing metals and that the plant processes currently utilized should not change even if the average flows increase some 30% (1.4 MGD to 2.0 MGD).
- The effluent limit established must result in the downstream concentrations after mixing of the stream and the WRF effluent achieving the chronic water quality standards.
- The zinc and cadmium loads from non-point sources will be reduced by 90% from implementation of best management practices (BMPs) outlined in sections 9.0 and 10.0.
- An explicit margin of safety of 25% is included to provide assurance that the uncertainty in the existing data set and effectiveness of the BMP implementation in meeting the 90% reduction goal are accounted for.

Zinc - Figure 23 depicts the required effluent concentration for zinc for the six seasons used for seasonal analysis. The most restrictive season of the year from a concentration perspective is the November through February time frame. The flow weighted mixing model results shown in Figure 23 indicate that the Nov/Dec time period effluent limit of 0.30 mg/l is the most stringent result over the entire year. If a 0.30 mg/l effluent limit is met for zinc throughout the year by the WRF, the downstream concentration of zinc after mixing with the stream should consistently achieve the hardness adjusted chronic water quality standard of 0.39 mg/l.

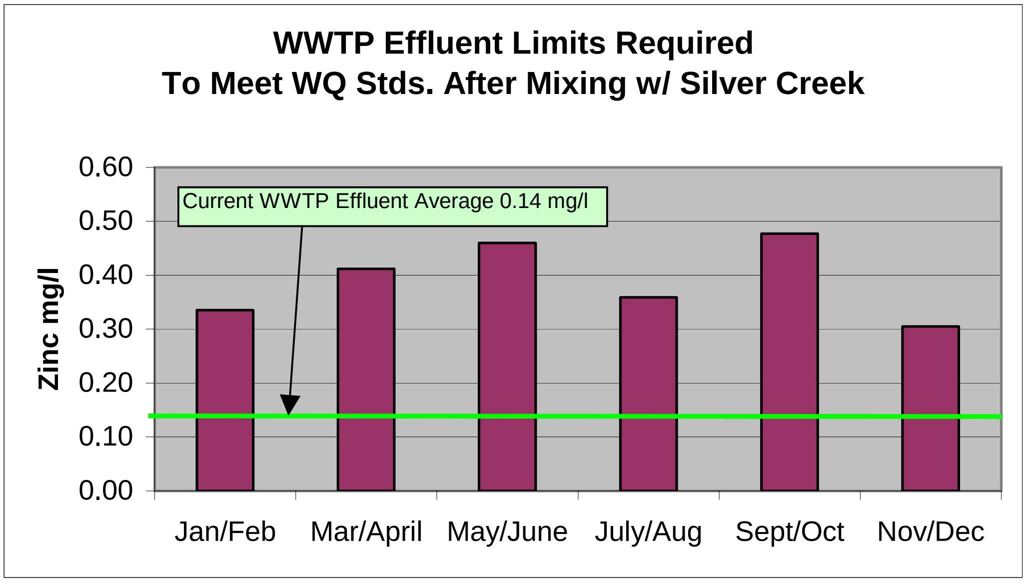

Figure 23: Silver Creek WRF Zinc Effluent Limit Needed to Achieve Water Quality Standards in Silver Creek after Mixing

Cadmium - The historical WRF effluent data for cadmium shows that virtually all of the values are below the detection limit. In order to be protective of the stream, an effluent limit that at least meets the new water quality standard should be imposed. It is unlikely that measurable contributions of cadmium will be detected from the Water Reclamation Facility.

Effluent Limit Implementation - The time-frame for including the proposed effluent limits for the Silver Creek WRF is not urgent given that currently, the non-point source loads dwarf the point source contribution. The current zinc loads from NPS sources will undoubtedly take 5 to 10 years for completion of the BMPs needed to address the NPS loads. Accordingly, the effluent limits for the Silver Creek WRF need not be in place until the NPS loads have been reduced by at least 75% of the target value through implementation of BMPs. Using zinc as the constituent of interest, this would translate into a load reduction of 7,760 lbs. needed at the "above Atkinson" station (or a total load of 2,556 lbs. of zinc measured at above Atkinson) to trigger the need for point source effluent limits to be in place.

9.0 BEST MANAGEMENT PRACTICES

The following sections describe Best Management Practices (BMPs) for the cleanup and/or isolation of mining contaminated materials from stream flows. The list is not all inclusive as specific site conditions may change, requiring changes to the specific BMPs, or additional BMPs not listed herein.

In general, there are two types of BMPs: source controls and treatment controls. Source controls focus on minimizing or eliminating the source of contamination so that contaminants are prevented from entering the stream system. Treatment controls are designed to remove a contaminant after it has entered the stream system.

A third type of BMP, ordinances, are discussed briefly within each control description and again in Section 10.0, Project Implementation Plan (PIP).

9.1 Source Control BMPs

Slope Protection

Slope protection BMPs are designed to minimize and protect exposed soil surfaces to help reduce erosion and the associated discharge of sediment to nearby streams. Sample slope protection BMPs include mulching, hydromulching, geotextile, matting, topsoiling, vegetating, and permanent surfacing. The use of cutoff ditches or swales at the top of the slopes is encouraged to keep runoff from entering the slope protection area.

Storm Runoff Routing

Storm runoff is responsible for carrying contaminated sediments from a contaminated site to the affected stream either by direct surface run-off or by percolating into the soil and eventually into the stream via groundwater. BMPs included in this category are measures designed to divert run-off from entering the site, keep run-off from leaving the site, or divert run-off away from sensitive sites. Sample BMPs include temporary sediment trapping measures (silt fencing, straw bales), swales/ditches, berms, dikes, and storm drain systems.

Isolation Measures

Isolation measures require that contaminated soils be isolated either onsite or removed to a "secure location." Isolating contaminated soils would include capping (above and below) with an impervious surface, i.e. clay, to prevent groundwater infiltration of contaminated run-off (percolation), diversion of run-off, and removal or enclosure (pipe) of stream channel through isolated area.

Additionally, contaminated sediments within the stream channels may have to be removed and relocated to a secure site if sediment transport is a concern. Sealing the stream channel with clay, bentonite, or other impervious material may keep contaminated stream flows from entering the ground water or contaminated groundwater from entering the stream flows.

Temporary Erosion Control

New construction activities will require permitting from the local, State, or Federal jurisdiction. Each jurisdiction should require an approved erosion control plan for stormwater pollution control. Sites with contaminated soils should fall under special scrutiny, i.e. Park City has a contaminated soil ordinance that requires that contaminated soils be addressed prior to construction. Temporary erosion control measures include silt fencing, hay bales, diversion ditches, temporary sedimentation/debris basins, channel protection (riprap, matting), and vegetative buffers. Some temporary measures, i.e. diversion ditches, may become part of the permanent erosion control measures.

9.2 Treatment Control BMPs

Water Treatment BMPs

Treatment BMPs are designed to remove contaminants/pollutants from flows (either run-off or stream) and return treated water to the receiving water, in this case Silver Creek. BMPs in this category include water/sediment separators, treatment wetlands, enhanced wetlands.

10.0 PROJECT IMPLEMENTATION PLAN

The Silver Creek TMDL water quality study has been a joint effort with numerous stakeholders. One of the significant regulatory programs involved along with the Utah Division of Water Quality is the EPA and State Superfund (CERCLA) programs. Given the historical mining wastes that are the primary sources for the water quality impairment, an approach that is similar to a Superfund RI/FS process is appropriate for this study. This TMDL lays out the endpoints or water quality goals for the watershed along with loading allocations needed to achieve the identified endpoints. However, it is not the intent of this TMDL to provide a detailed plan or program for clean up measures associated with historical mining in this watershed. The detailed analysis of clean up options and remedies along with determination of responsible parties is best handled in the Superfund arena.

Accordingly, the Implementation Measures that follow are only a very rough outline of possible approaches to remedy the water quality pollution present in Silver Creek. In this case, the PIP focuses on reducing the chronic levels of zinc and cadmium as listed in Table 12 (Section 8.0). Some of the approaches presented herein are worst case scenarios from a cost perspective and are in all likelihood too high to be considered. Much work is needed to identify the various alternatives for clean up, assign costs, assess feasibility and make a final determination. Accordingly, the detailed clean up plan and implementation for the Silver Creek Watershed will be handled by the EPA and State Superfund programs.

The following sections describe implementation measures, contaminant removal efficiencies, order of magnitude costs, and a broad-based implementation schedule.

10.1 Implementation Measures

The following implementation measures should be undertaken to successfully achieve the endpoints identified:

- *Slope Protection (stabilization)* – slopes containing contaminated mine tailings should be stabilized to prevent infiltration of water and dispersal of contaminants from run-off. Slope stabilization measures were discussed in Section 9.0.
- *Storm runoff routing* – The BMPs included in this category are measures designed to collect sediment produced onsite, divert run-on from entering the site, keep runoff from leaving the site, or divert runoff away from sensitive areas or certain site activities. Examples of measures are swales, berms, and detention/retention ponds.
- *Isolation measures* – areas that have been identified as containing contaminated mine tailings should be isolated to prevent further contamination of Silver Creek, ground water, and surrounding soils. Isolation measures will be dictated by the extent of the contamination as well as physical characteristics of the contaminated area. Measures can range from construction of diversion swales/ditches to re-route run-off, to removal of contaminated material and remediation of contaminated site. At a minimum, erosion control measures should be established to prevent run-off from entering and contaminated sediments from leaving contaminated sites.
- *Treatment Measures* – Contaminated flows can effectively be treated with the use of man-made or naturally occurring wetlands, i.e. Silver Maple Claims. Flows can be

routed into wetlands with the appropriately designed inlet/outlet structures to ensure adequate retention time for the biological removal of contaminants in the water column. Off–site or tributary flows, i.e. storm run-off, can be treated using local storm water programs, i.e. UPDES. Storm water can be managed using proper erosion control measures, following guidelines as established by the state and Federal governments, and ensuring that storm water controls are being applied as necessary.

- *Ordinances* – Local and State ordinances require the use of erosion control measures during construction or other disturbance activities. The Park City soil ordinance requires that contaminated soils, at construction sites, be isolated either by capping onsite or removal to an approved site. Federal ordinances, i.e. Superfund designation, would require full cleanup or stabilization of a site.

Table 13 describes the types of BMPs recommended and contaminant removal efficiencies within each BMP category.

Table 14: Best Management Practices – Description and Removal Efficiencies

BMPs	Description	Removal Efficiency	References
<u>Slope Protection (Stabilization)</u>			
topsoil	Imported topsoil placed at a minimum depth of 1 foot, sometimes seeded and treated to promote growth of vegetation.	84%	Strock, 1998; Georgia Stormwater Manual; Idaho BMPs
Geotextile or matting	Matting or fabric placed on steeper slopes for erosion control and to promote vegetation growth.	80%	Georgia Stormwater Manual; Idaho BMPs
revegetation	Seeding or placement of seed/mulch/compost mixture to promote vegetation growth and slope stabilization.	84%	Strock, 1998; Georgia Stormwater Manual; Idaho BMPs
hard surfacing	Pavement or other impermeable surface to prevent infiltration of water to contaminated soils.	100%	Georgia Stormwater Manual
<u>Storm Runoff Routing</u>			
grading to ensure positive drainage	Site grading to deter storm water from pooling on or entering contaminated site.	84%	Strock, 1998; Georgia Stormwater Manual; Idaho BMPs
Diversion ditches or berms	Ditches/swales/berms or other grading features to encourage water from entering contaminated sites or divert water to containment area within contaminated site.	84%	Strock, 1998; Georgia Stormwater Manual; Idaho BMPs
storm drain system	Use of storm drain system, i.e.: inlets, pipes, basins to route and	100%	N/A

BMPs	Description	Removal Efficiency	References
	contain runoff.		
detention/retention basins	Use of detention/retention basins to contain runoff onsite, possible allow sediments to settle out and be removed.	80%	Georgia Stormwater Manual; Idaho BMPs
Isolation Measures removal of contaminated soils	Removal of contaminated soils to approved "isolated" area.	100%	N/A
onsite capping of contaminated soils	Capping of contaminated soils on site using clay, topsoil, etc.	84%	Strock, 1998
clay-lined ditch or pipe	Using "sealed" ditch or pipe to convey stream flows. Sealed ditch or pipe will prevent infiltration to groundwater and possibly addition of further flows from storm runoff.	100%	N/A
Water Treatment wetland	Enhancement or creation of wetland either within the stream channel or off channel for the removal of heavy metals using select plant species.	>99%	Bolis, 1991
sediment basin	Use of sedimentation or stilling basin to allow sediments to settle out. Sediments can be removed from basin using excavating equipment and transported to an "isolated" site for final disposal.	80%	Strock, 1998; Georgia Stormwater Manual; Idaho BMPs
Ordinances Erosion Control during construction activities	NPDES, Local and State ordinance mandate temporary and permanent erosion control activities for all new construction. Disturbed areas shall be addressed to ensure that no sediment laden runoff is allowed to leave site.	80%	Georgia Stormwater Manual; Idaho BMPs
Park City Soil ordinance	Park City is aware of contaminated soils within City limits and has designated certain areas as "no or minimal disturbance". Contaminated soils are not allowed offsite and developers must address certain issues prior to receiving building permits.	80 – 100%	Georgia Stormwater Manual; Idaho BMPs
Superfund	Designation of a Superfund site would require full cleanup of that site. Cleanup could include removal or capping of contaminated soils.	Site specific requirements	CERCLA cleanup standards

N/A: Not Applicable

Further data gathering and analysis will more effectively identify contaminated areas and applicable BMPs to manage these areas. Management schedules can also be developed once further data have been gathered and there has been review of this document by stakeholders and the public.

10.2 Implementation Measures by Site

The following are site specific BMPs for the Silver Creek watershed. Sites are listed sequentially from headwater downstream.

Empire Canyon (Daly West Mine, Alliance Mine)

The following information was taken from the *Draft Engineering Evaluation/Cost Analysis for Empire Canyon, EPA ID No. 0002005981, March 2003.* (Draft EE/CA)

The Draft EE/CA established two response action objectives (RAOs) for Empire Canyon:

1. Isolation of surface water from mine wastes in the Empire Canyon Site.
2. Minimizing the potential for human exposure to elevated lead and arsenic concentrations on recreational trails.

The recommended response action for the site is a combination of:

1. Waste isolation with onsite repository; and
2. Waste isolation on UPCM property (Richardson Flat), removal and offsite disposal.

Waste isolation involves isolating surface water from mine wastes using the following methods:

- Excavating stream channels and reconstructing using riprap or culverts (Empire and Walker Webster stream channels).
- Lining sections of stream channels with clay liners to keep water on surface (no infiltration).
- Recreational trails containing contaminated soils will be covered with clean material. Some trail sections may be rerouted.
- The Daly West mine dump will be recontoured and covered with clean material. Some surface water flow in the vicinity of the mine dump will be re-routed to minimize contact with contaminated materials.
- Cut-off ditches will be placed upstream from the Daly West mine dump to intercept runoff from above the site.
- Surface water from the Empire, Daly Draw, and Walker Webster channels will be directed into a culvert and away from contaminated materials.

Mine waste removal and disposal:

- Approximately 4,500 linear feet of stream channel will be remediated.
- Approximately 2,500 linear feet of recreational trail will be remediated.
- Portions of the Alliance and Daly West mine dumps will be re-graded and capped with clean material.

- Excavated materials will be placed in an on site clay lined repository at the Daly West mine or transported offsite to Richarson Flat where it will be contained within a tailings impoundment.

The Draft EE/CA identifies the preferred alternative as being highly effective through the use of erosion control/storm water routing measures, topsoil and revegetation, clay lined channels, pipe culverts, and contaminated soil removal.

Daly West Mine (site inspection 11/8/2002)

The Daly West Mine is located on the ski area within several hundred feet of a chair lift. The site has been graded to promote drainage of run-off away from contaminated soils. Diversion ditches have been excavated to intercept and divert run-off away from contaminated soils. Portions of the area have been covered with topsoil and revegetated. Part of a parking lot has been paved , essentially covering and protecting the tailings.

Recommendations for this area include: analyze diversion ditches to determine the need for channel linings to prevent erosion by high water velocities; soil cover at a minimum of one foot depth; seed and treat soil to promote growth of vegetation; ensure that all drainage is diverted away from site.

Mine Office Area (site inspection 11/8/2002)

The area around the mine office is steeply sloped, unvegetated, and otherwise exposed to the elements. Some of the tailings have been covered by parking area and some topsoil. There is evidence of active erosion from run-off.

Recommendations include: regrading and covering the yard area with one foot of soil ensuring positive drainage away from the tailings, regraded area should be revegetated; the outer slope of the embankment (composed of mine spoil) should be regraded to a stable slope of 2H:1V, covered with a minimum of one foot of soil, limed, fertilized and revegetated; the roadside ditch (at the toe of regraded slope) may carry the run-off from the area to a sediment basin/wetland prior to its discharge into the area stream.

Empire Canyon (site inspection 11/8/2002)

Empire Canyon consists of a fairly large steep side slope covered by mine tailings. The stream channel is located a short distance from the toe of the slope. Rip rap has been placed within the channel for protection. Currently there is no run-off diversion, erosion control, vegetation or other form of slope protection.

Recommendations for this site range from onsite slope stabilization to removal of contaminated soils to a "secure" site.

- *Slope stabilization:* Slopes are fairly steep and would consequently not accept a layer of topsoil without extensive erosion control measures and constant maintenance. A more permanent surface would be required, i.e. shotcrete or gunnite. A diversion swale at the top of the slope to intercept and re-route run-off would also be required.

- *Removal of soils:* A secure location would have to be prepared prior to soil relocation. Securing a site would involve rerouting all runoff and placing an impermeable seal to prevent leachate from percolating and entering groundwater.
- *Stream isolation:* Stream reaches where contaminated run-off may come in contact with the stream could be isolated either by piping the stream at that location or providing diversion ditches at the toe of the slope to intercept contaminated run-off. Stream piping would take into consideration major flood events, seasonal flow variations, environmental permitting, and aesthetics. Diversion ditches at the toe of the slope would have to route water to a treatment facility prior to discharge to the stream. The treatment facility could be a separator or sedimentation basin. Treatment facilities typically have area and maintenance requirements.

Prospector Square (site inspection 11/8/2002)

Prospector Square is a developed area of Park City. It is home to several hotels, condominiums, restaurants, and shopping complexes. Shallow ground water is drained from Prospector Square is via buried pipe directly to an open water pond (sub-surface) upstream of the Silver Maple Claims area. Current BMPs include the Park City contaminated soil ordinance and the wetland complex. The Park City soil ordinance requires that developers address contaminated soils prior to construction. Contaminated soils can be "capped" onsite to prevent offsite transport of pollutants.

Recommended BMPs include: rerouting of the drainage pipe from Prospector Square away from Silver Creek to a constructed wetland area for treatment. The water from the treatment wetland will eventually make its way back to Silver Creek; enhance the existing wetland complex by enlarging the emergent marsh areas and by planting heavy metal removing plant species. Enhancement should also include site monitoring and maintenance. Additionally, ensuring that the Park City contaminated soil ordinance is enforced and that proper erosion control measures are employed during construction and other earth disturbing activities.

Silver Maple Claims (site inspection 11/8/2002)

Silver Maple Claims is located downstream of Park City and is comprised of a large wetland complex. The wetland complex includes open water and emergent marsh areas. Source of water into this area has been determined to be Silver Creek, groundwater, and ground water drainage from the Prospector Square area of Park City.

Wetlands, specifically wetland vegetation, have been shown to effectively remove heavy metals from water. Proper management of the wetland complex at Silver Maple Claims will ensure continued removal of contaminants from Silver Creek.

Flood Plains Tailings (site inspection 11/8/2002)

The flood plains tailings site is located on the north side of Silver Creek, between the Rail Trail and the access road to Richardson's Flat. The site is characterized by "perched" wetlands and scrub-shrub vegetation. The source of hydrology for the wetlands appears to be surface and ground water flowing from the west to the creek.

Recommended BMPs include: either removal of contaminated tailings and or construction of water control structures to manage surface flows from wetland complex to wetland complex and possibly to a constructed wetland area for treatment. Contaminated water within each wetland will become continuously cleaner as it is routed through the wetland complexes prior to discharge into the creek; enhance the existing wetland complexes by enlarging the emergent marsh areas and by planting heavy metal removing plant species. Enhancement should also include site monitoring and maintenance.

Richardson's Flat (site inspection 11/8/2002)

At this time, it is believed that Richardson's Flat is a minor contributor of contaminants to Silver Creek. Groundwater data including flows, flow direction, and contaminant concentrations is currently being collected and will be assessed by others in the future.

Above Atkinson (site inspection 11/8/2002)

The topography of the area is fairly flat for a 4-6 mile reach. The area is characterized by a slightly meandering stream channel, fairly wide vegetated flood channel, and widespread tailing deposits that includes some mounds of mine tailings. The stream channel runs through tailings for a stretch of approximately 4 miles in this meadow area. Anecdotal evidence suggests that tailings from the mines were brought to this area in an attempt to further extract valuable materials. One of the largest recovery operations in this area was the Big Four mill, in operation from approximately 1915 to 1918. The mill site has a large concentration of tailings depositions. There are currently no BMPs in place.

Recommended BMPs include: removal of all contaminated materials to a secure location; stabilizing and isolating contaminated materials onsite. This may not be practicable due to the large geographic extent of the area covered by the tailings. Additionally, groundwater contributes to the flows in Silver Creek through this reach. Isolating the tailings may affect groundwater flows; "seal" the creek bed using clay, bentonite, or some other material thus preventing flow to or from Silver Creek. Again, sealing the creek may adversely affect flows if ground water is isolated from the creek.

Other items to take into account when considering applicable BMPs are current irrigation practices. Numerous diversions exist along Silver Creek that allow farmers/ranchers to access water for irrigation and livestock use. The number of diversions and amount of water drawn from the creek are unknown at this time. Also unknown is whether diverted water has had adverse effects on surrounding soils or groundwater.

More data, i.e. groundwater, irrigation practices, soil analysis is required to effectively address the BMPs for this stretch of Silver Creek.

Silver Creek Water Reclamation Facility

Silver Creek WRF has historically been in compliance with state water quality standards for zinc and cadmium. Zinc values have averaged 0.14 mg/l and cadmium has never been detected at the site. It is expected that future patterns will be similar to historical ones. Cadmium levels should remain below the laboratory detection limit.

Below Atkinson (site inspection 11/8/2002)

This section of Silver Creek, as discussed in Section 4.4, does not appear to contribute to contaminant levels in the creek. BMPs implemented upstream from this section should have positive effects in contaminant levels. No BMPs are recommended at this time aside from continued monitoring.

10.3 Implementation Measures Efficiencies and Costs

Tables 14 and 15 present the BMP effectiveness and projected removal of zinc and cadmium for the five stream reaches of Silver Creek.

Table 15: BMP Effectiveness – Zinc removal

Stream Reach	Stream Reach Length (miles)	Zinc Annual Load (lbs)	Zinc Annual Load Reduction Needed (lbs)	Proposed BMP Removal Efficiency	Projected Zinc Total Removal (lbs)
Above Park City	2.6	1,859	989	80 - 100 %	1,487
Park City to Richardson Flat	3.4	4,905	2,642	85 – 99%	4,169
Richardson Flat to Above Atkinson	4.1	10,226	8,317	85 – 100%	8,692
Above Atkinson to Atkinson	0.5	12,142	7,332	85 – 100%	10,320
Atkinson to Wanship	7.5	8,014	2,479	[1]	2,479 [1].

1. Removal estimates in this reach are based on upstream reductions already achieved.

Table 16: BMP Effectiveness – Cadmium removal*

Stream Reach	Stream Reach Length (miles)	Cadmium Annual Load (lbs)	Cadmium Annual Load Reduction Needed (lbs)	Proposed BMP Removal Efficiency	Projected Cadmium Total Removal (lbs)
Above Park City	2.6	17.6	15.8	80 - 100 %	14
Park City to Richardson Flat	3.4	10.3	5.5	85 – 99%	8.7
Richardson Flat to Above Atkinson	4.1	25.8	22.1	85 – 100%	21.9
Above Atkinson to Atkinson	0.5	26.8	17.4	85 – 100%	22.8
Atkinson to Wanship	7.5	12.3	1.0	[1]	1.0 [1]

1. Removal estimates in this reach are based on upstream reductions already achieved.

*The same BMPs will be used for Cadmium as will be used for Zinc.

Costs

The following item costs and assumptions were used for calculating costs of BMP implementation:

*Excavation = $4/cu.yd.	Excavation is to a depth of 4 feet and includes hauling materials to a maximum distance of 5 miles.
*Topsoil = $3.50/sq.yd.	Topsoil includes materials and spreading. All excavated areas will be topsoiled.
*Lined Ditch = $50/ft.	Ditch/stream liner will be concrete or clay.
*36" Pipe Culvert = $60/ft	Includes placement.
*48" Pipe Culvert = $88/ft	Includes placement.
**Wetland Creation = $3/sq.ft.	Includes earthwork and vegetation

*Utah Department of Transportation - Statewide Standard Item Average Prices and Total Quantities 2002
**Brodie, 1993

For purposes of cost estimating, it is assumed that Silver Creek will either be placed in a lined ditch or in a 48" pipe culvert. A 48" pipe should accommodate anticipated flows, storm events etc., can overflow into the irrigation system and be retained at the irrigation holding pond to the north.

All contaminated soil will be excavated and removed to an approved repository (Richardson Flat). All disturbed areas shall be regraded and covered with topsoil.

Costs are summarized by stream reach below and presented in Table 16. All costs are based on estimated area and length measurements taken from readily available maps.

Table 17: Proposed BMPs, Efficiencies, and Costs

Reach	BMPs Proposed	BMP Efficiency (% contaminant removal)	BMP Cost
Above Park City (Empire Canyon)	Slope Protection Stabilization; Storm Runoff Routing; Isolation Measures	80 - 100 %	$1.17 million*
Park City to Richardson Flat	Slope Protection Stabilization; Storm Runoff Routing; Isolation Measures; Water Treatment; Ordinances	85 - 99 %	$7.93 million to $8.61 million
Richardson Flat to Above Atkinson	Storm Runoff Routing; Isolation Measures	85 – 99 %	$96.22 million to $97.05 million
Above Atkinson to Atkinson	Storm Runoff Routing; Isolation Measures	85 - 100 %	$9.06 million to $9.16 million
Atkinson to Wanship	None	n/a	n/a

*Cost estimate from Draft Empire Canyon EE/CA
n/a = not applicable

Above Park City

Cost estimates for this portion were calculated in the Draft Empire Canyon EE/CA at approximately $1.7 million.

Park City to Richardson Flat

Silver Maple Claim and Flood Plain Tails are included in this section.

The stream reach from Park City to Richardson Flat is approximately 3.4 miles in length. Isolation of the stream would require a pipe culvert or lined ditch/stream channel.

Lined ditch/stream = (3.4 miles)($50/ft) = $897,600.00
or 48” pipe culvert = (3.4 miles)($88/ft) = $1,579,776.00

The BLM proposes to move contaminated tailings from the Silver Maple Claim site to an approved repository. The area containing contaminated soils is approximately 60 acres is size. Approximately 387,197 cubic yards of material would be excavated and moved.

Excavation = (387,197 cu.yd.)($3.00/cu.yd.) = $1,161,591.00
<u>Top soil = (290,398 sq.yd.)($3.50/sq.yd.) = $1,016,393.00</u>
Excavation and Topsoil Total = $2,177,984.00

Contaminated tailings from the Floodplain Tails site would be moved to an approved repository. The area containing contaminated soils is approximately 130 acres is size. Approximately 838,927 cubic yards of material would be excavated and moved.

Excavation = (838,927 cu.yd.)($3.00/cu.yd.) = $2,516,781.00
<u>Top soil = (629,195 sq.yd.)($3.50/sq.yd.) = $2,202,183.50</u>
Excavation and Topsoil Total = $4,718,964.50

Wetland at Silver Maple Claims Complex

The Wetland is sized based on the maximum daily metal load (Zn and Cd) of 12.73 lbs/day (5774 gms/day) and metal removal capacity of 4.3 gms/day/m^2 of wetland surface area . Wetland area required is approximately 0.34 acres (1342 m^2).

(0.34 acres)(43560 sq. ft./acre)($3.00/sq.ft.) = $44,431.00

Wetlands at Flood Plain Tailings

The Wetland is sized based on the maximum daily metal load (Zn and Cd) of 27.18 lbs/day (12,329 gms/day) and metal removal capacity of 4.3 gms/day/m^2 of wetland surface area . Wetland area required is approximately 0.71 acres (2867 m^2).

(0.71 acres)(43560 sq. ft./acre)($3.00/sq.ft.) = $92,782.80

Richardson Flat to Above Atkinson

The stream reach from Richardson Flat to Above Atkinson is approximately 4.1 miles in length. Isolation of the stream would require a pipe culvert or lined ditch/stream channel.

Lined ditch/stream = (4.1 miles)($50/ft) = $1,082,400.00
or 48" pipe culvert = (4.1 miles)($88/ft) = $1,905,024.00

The area containing contaminated soils is approximately 2621 acres in size. Moving contaminated tailings material to an approved repository would involve the excavation of 16,914,070 cubic yards of material.

Excavation = (16,914,070 cu.yd.)($3.00/cu.yd.) = $50,742,210.00
Top soil = (12,685,540 sq.yd.)($3.50/sq.yd.) = $44,399,390.00
Excavation and Topsoil Total = $95,141,600.00

Above Atkinson to Atkinson
The stream reach from Above Atkinson to Atkinson is approximately 0.5 miles in length. Isolation of the stream would require a pipe culvert or lined ditch/stream channel.

Lined ditch/stream = (0.5 miles)($50/ft) = $132,000.00
or 48" pipe culvert = (0.5 miles)($88/ft) = $232,320.00

The area containing contaminated soils is approximately 246 acres in size. Moving contaminated tailings material to an approved repository would involve the excavation of 1,587,519 cubic yards of material.

Excavation = (1,587,519 cu.yd.)($3.00/cu.yd.) = $4,762,557.00
Top soil = (1,190,631 sq.yd.)($3.50/sq.yd.) = $4,167,208.50
Excavation and Topsoil Total = $8,929,765.50

*The preceding list of implementation measures and costs does not include possible wetland mitigation costs associated with the Army Corp of Engineers 404 permitting process. These costs would need to be developed on a project by project basis as more detailed planning is undertaken.

10.4 Implementation Schedule

Empire Canyon EE/CA - Fall 2003, clean up begins late Fall 2003, Spring 2004
BLM/Silver Maple Claim – Draft EE/CA Winter 2003, clean up begins Spring 2004
Richardson Flat – Decision document late 2003/early 2004 (EPA Action Memo regarding use of site for repository)
Prospector Square – new soils ordinance Fall 2003, ongoing monitoring (water in pipe) through Summer 2004.

All cleanup and containment of contaminated sites should be complete by 2009, assuming a five year cleanup period beginning January 2004.

11.0 TMDL EVALUATION AND MONITORING PLAN

An ongoing water quality monitoring program will be required to assess the affect of clean up and remediation work in the Silver Creek watershed. It is anticipated that as clean up progresses, metal concentrations in the water column will decrease proportionately. Since there is a degree of uncertainty regarding the actual effectiveness of any non-point source clean up, actual monitoring of water quality is the best measure of success. The table below outlines the monitoring program planned for Silver Creek over the next 5 years. The program establishes an intensive program every 5th year with quarterly monitoring in the intervening years. The Division of Water Quality will undertake the sampling and analysis responsibilities for this program.

Table 18: Division of Water Quality Monitoring Program for Silver Creek

Station	Storet No.	Frequency	No. of Samples	Parameters
SILVER CREEK AT CITY PARK ABOVE PROSPECTOR SQUARE	492695	2004 - 2007 Schedule B; 2003 & 2008 Schedule A	4 for Schedule A; 16 for Schedule B	Chemistry Type 2; Metals Type 3; Nutrient Type 9
SILVER CREEK AT US40 CROSSING EAST OF PARK CITY	492685	same as 492695	same as 492695	same as 492695
SILVER CREEK ABOVE ATKINSON	492680	same as 492695	same as 492695	same as 492695
SILVER CREEK WRF	492679	same as 492695	same as 492695	same as 492695
SILVER CREEK AT FARM CROSSING IN ATKINSON	492674	same as 492695	same as 492695	same as 492695
ALEXANDER CREEK AT HIGHWAY CROSSING	492670	same as 492695	same as 492695	same as 492695
SILVER CREEK AT WANSHIP ABOVE CONFLUENCE WITH WEBER RIVER	492675	same as 492695	same as 492695	same as 492695

Frequency

A. Biweekly March thru July; snowmelt to low flow (approx 9 events); monthly during low flow (approx August - Feb; 7 events.)

B. Quarterly

Parameters

Chemistry Type 2: Bicarbonate, Carbonate, Chloride, Hydroxide, pH, Specific Conductance, Sulfate, Total Alkalinity, Total Dissolved Solids, Total Hardness, Total Suspended Solids, and Turbidity.

Metals Type 3: Dissolved Aluminum, Arsenic, Barium, Cadmium, Chromium, Copper, Iron, Lead, Manganese, Mercury, Selenium, Silver, Zinc, Calcium, Magnesium, Potassium, Sodium

Nutrient Type 9: Ammonia, Dissolved Nitrite & Nitrate, Total Phosphorus, Total Dissolved Phosphorus

Results from the monitoring program will be reviewed annually and any adjustments needed to the program will be made.

12.0 PUBLIC PARTICIPATION

12.1 Public Participation Meetings

A public participation meeting was held on September 13, 2001 at the Miners Hospital Community Center in Park City, Utah. The public was notified of the meeting through the local news media. In addition, a letter of invitation was sent to local stakeholders and citizens to inform them of the public meeting. This meeting was designed to provide information and education on the TMDL process.

A public meeting was held on August 19, 2003 at the Empire Canyon Day Lodge at the Deer Valley Lodge at the Deer Valley Ski Resort in Park City, Utah. The purpose of the meeting was to present the Engineering Evaluation / Cost Analysis (EE/CA) required for cleanup work to begin in Empire Canyon. Details of the TMDL study were discussed at the public meeting.

12.2 Subcommittees and Groups

Throughout this project, the Upper Silver Creek Watershed Stakeholders Group functioned as the nucleus for the Technical Advisory Committee or Steering Committee. Several meetings were held by this group to discuss the development of the Silver Creek TMDL. Specifically, this committee was comprised of individuals that represent the interests of stakeholders in the Silver Creek watershed, including environmental engineering consultants, potential responsible parties, and representatives from state and federal government regulatory agencies.

The Upper Silver Creek Watershed Stakeholders Group was formed to investigate environmental issues related to hazardous substances in the Silver Creek Watershed and the Park City area. To provide a public information service and forum, the Upper Silver Creek Watershed Stakeholders Group operates a website: http://www.silvercreekpc.org. At the website, the public can learn more about the Silver Creek TMDL and can express opinions to the stakeholder group.

The Upper Silver Creek Watershed Stakeholders Group represents a wide range of interests that not only include community leaders, residents, and landowners, but also federal, state, and local governments. This stakeholder group is intended to provide a forum for discussion, not to create a voting or decision-making body. Membership is not closed and may be expanded beyond the membership listed below:

- Tom Bakaly, City Manager, Park City
- Kerry Gee, United Park City Mines
- Ty Howard, Utah Department of Environmental Quality
- John Whitehead, Utah Department of Environmental Quality
- Sally Elliot, Historic Preservation and Prospector Park
- Dana Williams, Mayor, Park City
- Bruce Waddell, US Fish and Wildlife Service
- Steve Jenkins and Pat Cone, Summit County
- Jim Christiansen, US Environmental Protection Agency
- Bob Wells, Deer Valley Mountain Resort

- Brian Strait, Park City Mountain Resort
- Mike Nelson and Tim Ingwell, Bureau of Land Management
- John Knudsen, Utah State Parks Division
- Chuck Hollingshead, Citizens for Responsible Growth
- Michael Luers, Snyderville Basin Water Reclamation District

Following the project kickoff meeting on March 20, 2001, the Upper Silver Creek Watershed Stakeholders Group held several meetings that included discussion of the development of the Silver Creek TMDL.

On March 18, 2003, the Upper Silver Creek Watershed Stakeholders Group held a meeting to discuss the completion of the Silver Creek TMDL.

On May 13, 2003, the Upper Silver Creek Watershed Stakeholders Group held a meeting to update the group on the efforts by the various entities involved – BLM, UPCM/EPA, DWQ (TMDL), Park City Municipal Corporation.

On July 8, 2003, the Upper Silver Creek Watershed Stakeholders Group held a meeting to discuss the status of the Empire Canyon EE/CA, Park City Soils Ordinance, and other documents recently released as part of the Silver Creek project.

13.0 REFERENCES

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Appendix A

Silver Creek Water Quality Data

Station	Site Description	Date	Cadmium (mg/l)	Zinc (mg/l)	Flow (cfs)
1001	USC-1, Rail Tressel @ U248	5/15/2000	0.000	**0.410**	5.2
1001	USC-1, Rail Tressel @ U248	9/27/2000	0.000	**0.720**	1.9
1001	USC-1, Rail Tressel @ U248	11/7/2000	0.000	**1.000**	0.8
1002	USC-2, Culvert @ U248	5/15/2000	0.000	0.330	
1002	USC-2, Culvert @ U248	9/27/2000	0.000	**0.710**	
1003	USC-3, Upstream RR Tressel	5/15/2000	**0.001**	**0.510**	3.3
1003	USC-3, Upstream RR Tressel	9/27/2000	0.000	**1.100**	1.7
1004	USC-32, Duplicate of USC-3	5/15/2000	**0.001**	**0.520**	
1005	USC-4, Diversion Ditch 50'	5/15/2000	0.000	0.000	0.1
1005	USC-4, Diversion Ditch 50'	9/27/2000	0.000	0.055	0.1
1005	USC-4, Diversion Ditch 50'	11/7/2000	0.000	0.100	0.1
1006	USC-5, N. Old Road to R.F.	5/15/2000	**0.001**	**0.950**	
1006	USC-5, N. Old Road to R.F.	9/27/2000	0.000	**2.000**	
1007	USC-6, Below Silvermaple	5/15/2000	0.000		
1007	USC-6, Below Silvermaple	9/27/2000	0.000	**0.640**	
1007	USC-6, Below Silvermaple	11/7/2000	0.000	**1.400**	
1008	USC-7, Above Silvermaple	5/15/2000	0.000	0.092	1.0
1008	USC-7, Above Silvermaple	9/27/2000	0.000	**0.460**	0.1
1008	USC-7, Above Silvermaple	11/7/2000	**0.007**	**2.100**	
1009	USC-8, State Sample Site	5/15/2000	**0.002**	0.270	1.6
1009	USC-8, State Sample Site	9/27/2000	0.000	0.067	0.4
1009	USC-8, State Sample Site	11/7/2000	**0.005**	0.360	
1010	USC-9, DV @ Confluence	5/16/2000	**0.021**	**1.100**	1.5
1010	USC-9, DV @ Confluence	9/27/2000	0.000	0.037	0.7
1011	USC-10, DV E. of Rd. Going S.	5/16/2000	0.000	0.120	1.8
1011	USC-10, DV E. of Rd. Going S.	9/27/2000	0.000	0.056	0.4
1012	USC-11, Emp.Cyn. @ culvert	5/16/2000	0.000	0.100	
1013	USC-12, Ont. Cyn. Merge w/Emp.	5/16/2000	**0.001**	**0.600**	0.1
1014	USC-13, Emp. Cyn. @ flow drain	5/16/2000	**0.044**	**5.300**	0.0
1015	USC-14, Flume Lower Ont. Cyn.	5/16/2000	**0.009**	**0.590**	0.1
1016	USC-15, Flume Emp. Cyn. Iron Gate	5/16/2000	**0.029**	**4.400**	0.1

1017	USC-17, Abv. Flume adj. Jude Tunnel	5/16/2000	0.000	0.011	0.0
1018	USC-25, Woodside Gulch	5/16/2000	0.000	0.040	
1019	USC-JT, Judge Tnl. Up. Daly#1 Shaft	5/16/2000	**0.002**	**0.730**	
1020	Empire 1, Upper Empire Canyon	5/16/2000	0.000	0.078	
1021	Ruby 1, Ruby Chairlift	5/16/2000	0.000	0.049	
1022	Ruby 2, Gulch North of Daly West	5/16/2000	**0.002**	0.130	
1023	USC-RC, Resort Center	5/22/2000	0.000	0.055	
1024	LBA, LittleBell Above	5/31/2000	0.000	0.027	
1025	LBB, LittleBell Below	5/31/2000	0.000	0.065	
1026	GET, Great East Tunnel	5/31/2000	0.000	0.053	
1027	TC-1, T. Cyn. Next to shaft dump	6/5/2000	**0.036**	**2.900**	
1028	CT-1, Comstock Tunnel	6/5/2000	**0.008**	**1.700**	
1029	USC-7, State Split	9/27/2000	0.000	**0.406**	
1030	USC-30	9/27/2000	0.000	**0.640**	
1031	Iron Horse 1	9/27/2000	0.000	0.065	
1032	Iron Horse 2	9/27/2000	0.000	0.059	
1033	Bonanza Dr.	9/27/2000	0.000	0.067	
1034	Ross 1	9/28/2000	0.000	0.033	
1035	DV-3	9/28/2000	0.000	0.045	
3001	Silver Creek Above Richardson Flats - USGS 2000	3/14/2000	**0.002**	**0.970**	
3001	Silver Creek Above Richardson Flats - USGS 2000	4/24/2000	**0.003**	**1.650**	
3001	Silver Creek Above Richardson Flats - USGS 2000	5/16/2000	0.000	**0.550**	
3001	Silver Creek Above Richardson Flats - USGS 2000	6/12/2000	**0.002**	**0.760**	
3001	Silver Creek Above Richardson Flats - USGS 2000	8/16/2000	**0.001**	**1.800**	
3002	Silver Creek At Atkinson - USGS 2000	3/10/2000	**0.002**	**1.170**	
3002	Silver Creek At Atkinson - USGS 2000	8/16/2000	0.000	0.100	
3003	Silver Creek At Wanship - USGS 2000	3/13/2000	**0.002**	**0.570**	
3003	Silver Creek At Wanship - USGS 2000	8/21/2000	0.000	0.160	
3004	Silver Creek At Bonanza Dr. - USGS 2000	3/10/2000	**0.004**	0.250	
3004	Silver Creek At Bonanza Dr. - USGS 2000	8/16/2000	0.000	0.090	
4001	SCS-5000 Silver Creek Above Richardson Flats - USGS 2002	5/1/2002		**0.729**	5.8
4002	SCS-5500 Silver Creek Below Richardson Flats - USGS 2002	5/1/2002		**0.694**	8.3

4003	SCS-6000 Silver Creek Above Silver Creek WWTP - USGS 2002	5/1/2002		**3.520**	1.0
4004	SCS-6500 Silver Creek At Atkinson (Below WWTP) - USGS 2002	5/1/2002		**1.630**	4.2
4005	SCS-7000 Silver Creek @ Wanship - USGS 2002	5/1/2002		0.243	19.0
492674	SILVER CK AT FARM XING IN ATKINSON	1/22/1991			3.7
492674	SILVER CK AT FARM XING IN ATKINSON	7/3/1991			0.5
492674	SILVER CK AT FARM XING IN ATKINSON	10/30/1991			
492674	SILVER CK AT FARM XING IN ATKINSON	1/22/1992			2.3
492674	SILVER CK AT FARM XING IN ATKINSON	4/15/1993			8.2
492674	SILVER CK AT FARM XING IN ATKINSON	4/28/1993			8.5
492674	SILVER CK AT FARM XING IN ATKINSON	5/11/1993			32.8
492674	SILVER CK AT FARM XING IN ATKINSON	5/27/1993			21.4
492674	SILVER CK AT FARM XING IN ATKINSON	7/20/1993			1.0
492674	SILVER CK AT FARM XING IN ATKINSON	10/27/1993			4.8
492674	SILVER CK AT FARM XING IN ATKINSON	2/17/1994			3.0
492674	SILVER CK AT FARM XING IN ATKINSON	4/19/1994			3.5
492674	SILVER CK AT FARM XING IN ATKINSON	6/14/1994			7.0
492674	SILVER CK AT FARM XING IN ATKINSON	8/9/1994			1.7
492674	SILVER CK AT FARM XING IN ATKINSON	11/15/1994			3.8
492674	SILVER CK AT FARM XING IN ATKINSON	1/12/1995			1.8
492674	SILVER CK AT FARM XING IN ATKINSON	4/6/1995			4.8
492674	SILVER CK AT FARM XING IN ATKINSON	8/15/1995			3.5
492674	SILVER CK AT FARM XING IN ATKINSON	11/21/1995			7.0
492674	SILVER CK AT FARM XING IN ATKINSON	2/1/1996	**0.004**	**1.500**	5.0
492674	SILVER CK AT FARM XING IN ATKINSON	6/13/1996	0.000	0.260	2.5
492674	SILVER CK AT FARM XING IN ATKINSON	8/1/1996	0.000	0.240	3.0
492674	SILVER CK AT FARM XING IN ATKINSON	10/22/1996	**0.001**	**0.620**	5.4
492674	SILVER CK AT FARM XING IN ATKINSON	2/4/1997	**0.006**	**1.800**	7.0
492674	SILVER CK AT FARM XING IN ATKINSON	5/14/1997	**0.006**	**1.100**	18.0
492674	SILVER CK AT FARM XING IN ATKINSON	8/6/1997	0.000	0.074	9.0
492674	SILVER CK AT FARM XING IN ATKINSON	10/21/1997	0.000	**0.500**	6.0
492674	SILVER CK AT FARM XING IN ATKINSON	1/29/1998	**0.001**	**1.000**	2.0

492674	SILVER CK AT FARM XING IN ATKINSON	4/14/1998	**0.003**	**1.100**	4.0
492674	SILVER CK AT FARM XING IN ATKINSON	7/23/1998	0.000	0.260	3.4
492674	SILVER CK AT FARM XING IN ATKINSON	10/29/1998	**0.001**	**0.570**	4.0
492674	SILVER CK AT FARM XING IN ATKINSON	1/22/1999	**0.002**	**0.990**	9.0
492674	SILVER CK AT FARM XING IN ATKINSON	4/14/1999	0.000	**0.570**	5.6
492674	SILVER CK AT FARM XING IN ATKINSON	11/3/1999	0.000	0.370	4.5
492674	SILVER CK AT FARM XING IN ATKINSON	1/6/2000	0.000	**0.500**	3.5
492674	SILVER CK AT FARM XING IN ATKINSON	4/13/2000	0.000	0.387	4.5
492674	SILVER CK AT FARM XING IN ATKINSON	8/24/2000	0.000	0.173	3.0
492674	SILVER CK AT FARM XING IN ATKINSON	11/1/2000	**0.004**	**2.720**	9.8
492674	SILVER CK AT FARM XING IN ATKINSON	1/30/2001	**0.003**	**1.630**	3.5
492674	SILVER CK AT FARM XING IN ATKINSON	5/16/2001	**0.003**	**1.260**	13.4
492674	SILVER CK AT FARM XING IN ATKINSON	7/20/2001	0.000	0.129	0.5
492674	SILVER CK AT FARM XING IN ATKINSON	8/1/2001	0.000	0.073	2.4
492674	SILVER CK AT FARM XING IN ATKINSON	9/6/2001	0.000	0.093	2.9
492674	SILVER CK AT FARM XING IN ATKINSON	10/4/2001	0.000	0.135	7.7
492674	SILVER CK AT FARM XING IN ATKINSON	11/8/2001	**0.001**	**0.849**	6.0
492674	SILVER CK AT FARM XING IN ATKINSON	12/11/2001	**0.005**	**2.420**	3.8
492674	SILVER CK AT FARM XING IN ATKINSON	1/9/2002	**0.005**	**1.470**	4.5
492674	SILVER CK AT FARM XING IN ATKINSON	2/5/2002	**0.004**	**1.760**	3.0
492674	SILVER CK AT FARM XING IN ATKINSON	3/21/2002	**0.005**	**1.880**	9.5
492674	SILVER CK AT FARM XING IN ATKINSON	4/11/2002	**0.005**	**1.430**	
492674	SILVER CK AT FARM XING IN ATKINSON	5/16/2002	**0.002**	**0.491**	
492674	SILVER CK AT FARM XING IN ATKINSON	8/13/2002			3.1
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	1/17/1990			5.6
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	2/15/1990			3.6
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	4/5/1990			8.6
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	5/17/1990			7.3
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	6/19/1990			3.3
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	9/6/1990			2.7
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	10/10/1990			2.0
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	12/11/1990			4.3

492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	2/20/1991			11.5
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	5/8/1991			26.0
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	6/27/1991			4.8
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	8/8/1991			3.2
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	10/8/1991			4.5
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	11/26/1991			9.4
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	1/30/1992			4.3
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	3/18/1992			6.2
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	4/21/1992			4.3
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	6/24/1992	0.000	0.150	1.7
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	8/6/1992	**0.001**	0.240	1.2
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	9/24/1992	**0.002**	0.220	1.8
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	11/5/1992	0.000	**0.500**	5.3
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	1/21/1993	0.000	**0.720**	3.8
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	4/1/1993	**0.005**	**1.700**	38.0
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	4/15/1993	**0.003**	**1.400**	6.9
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	4/29/1993			26.7
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	5/11/1993			22.0
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	5/27/1993			7.0
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	6/9/1993			5.8
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	7/20/1993	**0.002**	0.300	3.3
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	8/24/1993			6.2
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	9/23/1993			4.9
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	10/27/1993			8.3
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	11/23/1993	**0.001**	**0.550**	3.7
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	1/12/1994	**0.001**	**0.580**	2.9
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	2/17/1994	**0.001**	**0.730**	4.4
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	3/23/1994			14.0
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	4/5/1994	0.000	**0.490**	13.0
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	4/20/1994			11.0
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	5/3/1994			14.0

492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	5/17/1994			10.0
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	6/2/1994			4.7
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	6/14/1994			2.2
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	7/22/1998	**0.001**	0.156	5.0
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	8/27/1998			10.0
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	10/1/1998			4.0
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	10/29/1998	0.000	0.200	5.0
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	12/17/1998			10.0
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	1/21/1999	0.000	0.240	5.0
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	2/18/1999			6.0
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	3/26/1999			29.9
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	4/16/1999	0.000	0.150	8.0
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	4/29/1999			75.6
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	5/14/1999			86.9
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	6/3/1999			59.3
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	6/17/1999			12.0
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	8/1/2001	**0.001**	0.147	4.3
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	9/6/2001	0.000	0.109	3.0
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	10/4/2001	0.000	0.102	3.5
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	11/6/2001	0.000	0.123	4.0
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	12/11/2001	**0.001**	**0.712**	4.2
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	1/9/2002	0.000	**0.508**	17.6
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	2/5/2002	0.000	**0.820**	
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	3/21/2002	**0.001**	**0.537**	13.9
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	4/11/2002	0.000	0.383	20.6
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	4/25/2002	0.000	0.262	
492675	SILVER CK AT WANSHIP AB CNFL / WEBER R	5/16/2002	0.000	0.058	11.5
492679	SILVER CREEK WWTP	1/18/1990			1.5
492679	SILVER CREEK WWTP	1/25/1990			
492679	SILVER CREEK WWTP	4/5/1990			1.4
492679	SILVER CREEK WWTP	5/17/1990			0.9
492679	SILVER CREEK WWTP	6/19/1990			1.2

492679	SILVER CREEK WWTP	9/6/1990			2.0
492679	SILVER CREEK WWTP	10/10/1990			0.5
492679	SILVER CREEK WWTP	12/11/1990			0.6
492679	SILVER CREEK WWTP	1/22/1991			1.6
492679	SILVER CREEK WWTP	2/20/1991			2.1
492679	SILVER CREEK WWTP	5/8/1991			1.1
492679	SILVER CREEK WWTP	7/3/1991			1.7
492679	SILVER CREEK WWTP	8/8/1991			1.5
492679	SILVER CREEK WWTP	10/8/1991			1.4
492679	SILVER CREEK WWTP	10/30/1991			
492679	SILVER CREEK WWTP	11/26/1991			1.3
492679	SILVER CREEK WWTP	1/22/1992			
492679	SILVER CREEK WWTP	1/30/1992			1.5
492679	SILVER CREEK WWTP	3/18/1992			2.5
492679	SILVER CREEK WWTP	4/21/1992			1.2
492679	SILVER CREEK WWTP	6/24/1992			1.8
492679	SILVER CREEK WWTP	8/6/1992			2.5
492679	SILVER CREEK WWTP	9/24/1992			2.2
492679	SILVER CREEK WWTP	11/5/1992			1.5
492679	SILVER CREEK WWTP	1/21/1993			1.9
492679	SILVER CREEK WWTP	4/1/1993			4.0
492679	SILVER CREEK WWTP	4/15/1993			2.6
492679	SILVER CREEK WWTP	4/28/1993			2.6
492679	SILVER CREEK WWTP	5/11/1993			2.5
492679	SILVER CREEK WWTP	5/27/1993			2.2
492679	SILVER CREEK WWTP	6/9/1993			0.0
492679	SILVER CREEK WWTP	7/20/1993			2.0
492679	SILVER CREEK WWTP	8/24/1993			2.6
492679	SILVER CREEK WWTP	9/22/1993			2.0
492679	SILVER CREEK WWTP	10/27/1993			1.7
492679	SILVER CREEK WWTP	11/23/1993			1.2

492679	SILVER CREEK WWTP	1/12/1994			2.0
492679	SILVER CREEK WWTP	2/17/1994			1.9
492679	SILVER CREEK WWTP	4/19/1994			1.9
492679	SILVER CREEK WWTP	6/14/1994			1.5
492679	SILVER CREEK WWTP	8/9/1994			2.6
492679	SILVER CREEK WWTP	9/20/1994			0.8
492679	SILVER CREEK WWTP	11/15/1994			1.2
492679	SILVER CREEK WWTP	1/12/1995			2.9
492679	SILVER CREEK WWTP	2/15/1995			2.1
492679	SILVER CREEK WWTP	4/6/1995			2.5
492679	SILVER CREEK WWTP	5/16/1995			2.7
492679	SILVER CREEK WWTP	8/15/1995			2.2
492679	SILVER CREEK WWTP	9/28/1995			1.5
492679	SILVER CREEK WWTP	11/21/1995			2.8
492679	SILVER CREEK WWTP	2/1/1996			2.6
492679	SILVER CREEK WWTP	3/6/1996			4.0
492679	SILVER CREEK WWTP	4/17/1996			2.8
492679	SILVER CREEK WWTP	6/13/1996			2.8
492679	SILVER CREEK WWTP	8/1/1996			1.7
492679	SILVER CREEK WWTP	9/12/1996			1.2
492679	SILVER CREEK WWTP	10/22/1996			1.1
492679	SILVER CREEK WWTP	12/4/1996			1.4
492679	SILVER CREEK WWTP	2/4/1997			2.2
492679	SILVER CREEK WWTP	3/25/1997			2.3
492679	SILVER CREEK WWTP	7/10/1997			1.7
492679	SILVER CREEK WWTP	8/6/1997			1.9
492679	SILVER CREEK WWTP	9/25/1997			1.3
492679	SILVER CREEK WWTP	10/21/1997			2.0
492679	SILVER CREEK WWTP	12/11/1997			1.2
492679	SILVER CREEK WWTP	1/29/1998	0.000	0.110	2.3
492679	SILVER CREEK WWTP	3/5/1998			2.2

492679	SILVER CREEK WWTP	4/14/1998	0.000	0.330	2.9
492679	SILVER CREEK WWTP	7/23/1998	0.000	0.136	2.3
492679	SILVER CREEK WWTP	8/27/1998			4.8
492679	SILVER CREEK WWTP	10/1/1998			2.0
492679	SILVER CREEK WWTP	10/29/1998			2.4
492679	SILVER CREEK WWTP	12/17/1998			1.5
492679	SILVER CREEK WWTP	1/22/1999			1.7
492679	SILVER CREEK WWTP	2/18/1999			3.1
492679	SILVER CREEK WWTP	4/14/1999	0.000	0.150	1.7
492679	SILVER CREEK WWTP	4/29/1999			2.4
492679	SILVER CREEK WWTP	5/14/1999			2.2
492679	SILVER CREEK WWTP	6/3/1999			1.9
492679	SILVER CREEK WWTP	6/17/1999			2.0
492679	SILVER CREEK WWTP	11/3/1999			
492679	SILVER CREEK WWTP	1/6/2000			2.5
492679	SILVER CREEK WWTP	2/24/2000			2.5
492679	SILVER CREEK WWTP	4/13/2000			2.1
492679	SILVER CREEK WWTP	6/13/2000			0.6
492679	SILVER CREEK WWTP	8/24/2000			1.1
492679	SILVER CREEK WWTP	9/26/2000			1.1
492679	SILVER CREEK WWTP	11/1/2000			1.4
492679	SILVER CREEK WWTP	1/30/2001			3.0
492679	SILVER CREEK WWTP	5/16/2001			2.8
492679	SILVER CREEK WWTP	7/20/2001			2.7
492679	SILVER CREEK WWTP	8/1/2001	0.000	0.099	1.5
492679	SILVER CREEK WWTP	9/6/2001	0.000	0.097	2.6
492679	SILVER CREEK WWTP	10/4/2001	0.000	0.101	2.2
492679	SILVER CREEK WWTP	11/8/2001	0.000	0.120	1.8
492679	SILVER CREEK WWTP	12/11/2001	0.000	0.089	2.8
492679	SILVER CREEK WWTP	1/9/2002	0.000	0.085	2.6
492679	SILVER CREEK WWTP	2/5/2002	0.000	0.083	2.9
492679	SILVER CREEK WWTP	2/20/2002			4.6

492679	SILVER CREEK WWTP	3/21/2002			3.2
492679	SILVER CREEK WWTP	4/11/2002	0.000	0.187	3.2
492679	SILVER CREEK WWTP	4/25/2002	0.000	0.194	
492679	SILVER CREEK WWTP	5/16/2002			2.2
492679	SILVER CREEK WWTP	6/26/2002			2.6
492679	SILVER CREEK WWTP	8/13/2002			3.1
492680	SILVER CK AB ATKINSON	1/25/1990			
492680	SILVER CK AB ATKINSON	4/5/1990			1.6
492680	SILVER CK AB ATKINSON	5/17/1990			4.0
492680	SILVER CK AB ATKINSON	6/19/1990			1.4
492680	SILVER CK AB ATKINSON	9/6/1990			0.0
492680	SILVER CK AB ATKINSON	10/10/1990			4.4
492680	SILVER CK AB ATKINSON	12/11/1990			1.8
492680	SILVER CK AB ATKINSON	2/20/1991			8.3
492680	SILVER CK AB ATKINSON	5/8/1991			3.0
492680	SILVER CK AB ATKINSON	8/8/1991			
492680	SILVER CK AB ATKINSON	10/8/1991			5.0
492680	SILVER CK AB ATKINSON	7/23/1998			1.0
492680	SILVER CK AB ATKINSON	10/29/1998	0.000	0.087	0.4
492680	SILVER CK AB ATKINSON	4/14/1999	**0.001**	**0.600**	3.9
492680	SILVER CK AB ATKINSON	11/3/1999	0.000	0.300	1.8
492680	SILVER CK AB ATKINSON	1/6/2000	0.000	**0.670**	
492680	SILVER CK AB ATKINSON	4/13/2000	0.000	**0.765**	1.3
492680	SILVER CK AB ATKINSON	8/24/2000	0.000	**0.568**	1.5
492680	SILVER CK AB ATKINSON	11/1/2000	**0.008**	**3.630**	4.7
492680	SILVER CK AB ATKINSON	1/30/2001	**0.001**	**0.694**	
492680	SILVER CK AB ATKINSON	5/16/2001	**0.003**	**1.100**	10.4
492680	SILVER CK AB ATKINSON	8/1/2001			0.0
492680	SILVER CK AB ATKINSON	9/6/2001	0.000	0.054	0.3
492680	SILVER CK AB ATKINSON	10/4/2001	0.000	0.000	0.2
492680	SILVER CK AB ATKINSON	11/8/2001	**0.008**	**2.320**	4.2
492680	SILVER CK AB ATKINSON	12/11/2001	**0.019**	**6.350**	1.8

492680	SILVER CK AB ATKINSON	1/9/2002	**0.011**	**2.880**	2.5
492680	SILVER CK AB ATKINSON	2/5/2002	**0.019**	**7.340**	1.0
492680	SILVER CK AB ATKINSON	3/21/2002	**0.007**	**2.970**	0.9
492680	SILVER CK AB ATKINSON	4/11/2002	**0.010**	**2.580**	4.0
492680	SILVER CK AB ATKINSON	5/16/2002	**0.004**	**0.808**	2.0
492680	SILVER CK AB ATKINSON	8/13/2002			0.0
492685	SILVER CK AT US40 XING E OF PARK CITY	7/3/1991			
492685	SILVER CK AT US40 XING E OF PARK CITY	10/30/1991			
492685	SILVER CK AT US40 XING E OF PARK CITY	11/26/1991			4.0
492685	SILVER CK AT US40 XING E OF PARK CITY	1/30/1992			
492685	SILVER CK AT US40 XING E OF PARK CITY	3/18/1992			1.9
492685	SILVER CK AT US40 XING E OF PARK CITY	4/21/1992			3.5
492685	SILVER CK AT US40 XING E OF PARK CITY	6/24/1992	0.000	0.069	0.3
492685	SILVER CK AT US40 XING E OF PARK CITY	8/6/1992	0.000	0.330	0.3
492685	SILVER CK AT US40 XING E OF PARK CITY	9/24/1992	**0.001**	**0.540**	0.3
492685	SILVER CK AT US40 XING E OF PARK CITY	11/5/1992	**0.002**	**1.400**	2.1
492685	SILVER CK AT US40 XING E OF PARK CITY	1/21/1993	**0.002**	**1.200**	
492685	SILVER CK AT US40 XING E OF PARK CITY	4/8/1993	**0.010**	**2.600**	9.5
492685	SILVER CK AT US40 XING E OF PARK CITY	4/15/1993	**0.006**	**1.400**	4.9
492685	SILVER CK AT US40 XING E OF PARK CITY	4/28/1993			7.0
492685	SILVER CK AT US40 XING E OF PARK CITY	5/11/1993			18.0
492685	SILVER CK AT US40 XING E OF PARK CITY	5/27/1993			19.4
492685	SILVER CK AT US40 XING E OF PARK CITY	6/9/1993			16.7
492685	SILVER CK AT US40 XING E OF PARK CITY	7/20/1993	**0.002**	**0.700**	3.9
492685	SILVER CK AT US40 XING E OF PARK CITY	8/24/1993			3.0
492685	SILVER CK AT US40 XING E OF PARK CITY	9/22/1993			3.4
492685	SILVER CK AT US40 XING E OF PARK CITY	10/27/1993	**0.004**	**1.200**	2.5
492685	SILVER CK AT US40 XING E OF PARK CITY	11/23/1993	**0.003**	**1.100**	1.2
492685	SILVER CK AT US40 XING E OF PARK CITY	1/12/1994	**0.004**	**1.200**	
492685	SILVER CK AT US40 XING E OF PARK CITY	2/17/1994	**0.002**	**0.960**	2.0
492685	SILVER CK AT US40 XING E OF PARK CITY	3/23/1994			8.5

492685	SILVER CK AT US40 XING E OF PARK CITY	4/5/1994	**0.002**	**1.300**	3.5
492685	SILVER CK AT US40 XING E OF PARK CITY	4/19/1994			4.5
492685	SILVER CK AT US40 XING E OF PARK CITY	5/3/1994			9.0
492685	SILVER CK AT US40 XING E OF PARK CITY	5/17/1994			2.0
492685	SILVER CK AT US40 XING E OF PARK CITY	6/2/1994			7.6
492685	SILVER CK AT US40 XING E OF PARK CITY	6/14/1994			2.0
492685	SILVER CK AT US40 XING E OF PARK CITY	8/9/1994			1.8
492685	SILVER CK AT US40 XING E OF PARK CITY	11/15/1994			0.3
492685	SILVER CK AT US40 XING E OF PARK CITY	1/12/1995			1.0
492685	SILVER CK AT US40 XING E OF PARK CITY	4/6/1995			3.8
492685	SILVER CK AT US40 XING E OF PARK CITY	8/15/1995			1.5
492685	SILVER CK AT US40 XING E OF PARK CITY	11/21/1995			3.3
492685	SILVER CK AT US40 XING E OF PARK CITY	1/24/1996			5.0
492685	SILVER CK AT US40 XING E OF PARK CITY	6/13/1996	**0.002**	**0.670**	2.0
492685	SILVER CK AT US40 XING E OF PARK CITY	8/1/1996	**0.002**	**0.610**	2.5
492685	SILVER CK AT US40 XING E OF PARK CITY	10/22/1996	0.000	0.350	1.8
492685	SILVER CK AT US40 XING E OF PARK CITY	2/3/1997	**0.003**	**0.990**	5.0
492685	SILVER CK AT US40 XING E OF PARK CITY	5/14/1997	**0.002**	**0.620**	12.0
492685	SILVER CK AT US40 XING E OF PARK CITY	8/6/1997			0.0
492685	SILVER CK AT US40 XING E OF PARK CITY	9/25/1997	0.000	0.270	3.0
492685	SILVER CK AT US40 XING E OF PARK CITY	10/21/1997	0.000	**0.490**	3.5
492685	SILVER CK AT US40 XING E OF PARK CITY	1/29/1998			0.0
492685	SILVER CK AT US40 XING E OF PARK CITY	3/5/1998	**0.003**	**0.970**	2.0
492685	SILVER CK AT US40 XING E OF PARK CITY	4/14/1998	**0.003**	**1.100**	3.0
492685	SILVER CK AT US40 XING E OF PARK CITY	7/23/1998	0.000	0.280	3.5
492685	SILVER CK AT US40 XING E OF PARK CITY	8/27/1998			2.0
492685	SILVER CK AT US40 XING E OF PARK CITY	10/1/1998			2.0
492685	SILVER CK AT US40 XING E OF PARK CITY	10/29/1998	**0.002**	**0.810**	1.5
492685	SILVER CK AT US40 XING E OF PARK CITY	12/17/1998			2.0
492685	SILVER CK AT US40 XING E OF PARK CITY	1/22/1999	**0.002**	**0.930**	
492685	SILVER CK AT US40 XING E OF PARK CITY	2/18/1999	**0.003**	**0.880**	1.0

492685	SILVER CK AT US40 XING E OF PARK CITY	3/26/1999			3.5
492685	SILVER CK AT US40 XING E OF PARK CITY	4/14/1999	**0.001**	**0.400**	1.0
492685	SILVER CK AT US40 XING E OF PARK CITY	4/29/1999			7.5
492685	SILVER CK AT US40 XING E OF PARK CITY	5/14/1999	**0.002**	**0.460**	
492685	SILVER CK AT US40 XING E OF PARK CITY	6/3/1999			15.0
492685	SILVER CK AT US40 XING E OF PARK CITY	6/17/1999	0.000	0.260	3.5
492685	SILVER CK AT US40 XING E OF PARK CITY	8/1/2001			0.0
492685	SILVER CK AT US40 XING E OF PARK CITY	9/6/2001	0.000	0.175	0.3
492685	SILVER CK AT US40 XING E OF PARK CITY	10/4/2001	0.000	0.224	0.4
492685	SILVER CK AT US40 XING E OF PARK CITY	11/8/2001	**0.002**	**0.952**	0.2
492685	SILVER CK AT US40 XING E OF PARK CITY	12/11/2001	**0.003**	**0.956**	1.0
492685	SILVER CK AT US40 XING E OF PARK CITY	1/9/2002	**0.002**	**0.686**	0.5
492685	SILVER CK AT US40 XING E OF PARK CITY	2/5/2002	**0.001**	**1.380**	0.5
492685	SILVER CK AT US40 XING E OF PARK CITY	3/21/2002	**0.001**	**0.735**	0.8
492685	SILVER CK AT US40 XING E OF PARK CITY	4/11/2002	**0.004**	**1.240**	4.0
492685	SILVER CK AT US40 XING E OF PARK CITY	4/25/2002	**0.001**	**0.555**	
492685	SILVER CK AT US40 XING E OF PARK CITY	5/16/2002	**0.001**	0.351	2.0
492695	SILVER CK @ CITY PARK AB PROSPECTOR SQUARE	8/6/1997			0.0
492695	SILVER CK @ CITY PARK AB PROSPECTOR SQUARE	9/25/1997	0.000	0.110	0.0
492695	SILVER CK @ CITY PARK AB PROSPECTOR SQUARE	10/21/1997	**0.005**	**0.690**	1.2
492695	SILVER CK @ CITY PARK AB PROSPECTOR SQUARE	12/11/1997	0.000	0.160	0.2
492695	SILVER CK @ CITY PARK AB PROSPECTOR SQUARE	1/29/1998	**0.001**	0.230	0.5
492695	SILVER CK @ CITY PARK AB PROSPECTOR SQUARE	4/14/1998	**0.011**	**0.980**	1.0
492695	SILVER CK @ CITY PARK AB PROSPECTOR SQUARE	7/23/1998	**0.006**	**0.450**	0.4
492695	SILVER CK @ CITY PARK AB PROSPECTOR SQUARE	8/27/1998			0.8
492695	SILVER CK @ CITY PARK AB PROSPECTOR SQUARE	10/1/1998			0.1
492695	SILVER CK @ CITY PARK AB PROSPECTOR SQUARE	10/29/1998	0.000	0.087	0.5
492695	SILVER CK @ CITY PARK AB PROSPECTOR SQUARE	12/17/1998			0.0
492695	SILVER CK @ CITY PARK AB PROSPECTOR SQUARE	1/21/1999			0.0
492695	SILVER CK @ CITY PARK AB PROSPECTOR SQUARE	2/18/1999	**0.006**	**0.470**	0.5
492695	SILVER CK @ CITY PARK AB PROSPECTOR SQUARE	3/26/1999			2.5

492695	SILVER CK @ CITY PARK AB PROSPECTOR SQUARE	4/14/1999	**0.011**	**0.540**	1.0
492695	SILVER CK @ CITY PARK AB PROSPECTOR SQUARE	4/29/1999	**0.005**	**0.530**	15.0
492695	SILVER CK @ CITY PARK AB PROSPECTOR SQUARE	5/14/1999	**0.012**	**1.200**	10.0
492695	SILVER CK @ CITY PARK AB PROSPECTOR SQUARE	6/3/1999	**0.005**	**0.550**	10.0
492695	SILVER CK @ CITY PARK AB PROSPECTOR SQUARE	6/17/1999	**0.006**	**0.630**	3.0
492695	SILVER CK @ CITY PARK AB PROSPECTOR SQUARE	8/1/2001	0.000	0.097	0.1
492695	SILVER CK @ CITY PARK AB PROSPECTOR SQUARE	9/6/2001	0.000	0.147	0.6
492695	SILVER CK @ CITY PARK AB PROSPECTOR SQUARE	10/4/2001	**0.006**	**1.010**	2.4
492695	SILVER CK @ CITY PARK AB PROSPECTOR SQUARE	11/8/2001	**0.003**	**0.616**	3.0
492695	SILVER CK @ CITY PARK AB PROSPECTOR SQUARE	12/11/2001	**0.006**	**0.754**	0.3
492695	SILVER CK @ CITY PARK AB PROSPECTOR SQUARE	1/9/2002	**0.003**	**0.392**	1.0
492695	SILVER CK @ CITY PARK AB PROSPECTOR SQUARE	2/5/2002	**0.002**	**0.456**	0.5
492695	SILVER CK @ CITY PARK AB PROSPECTOR SQUARE	2/11/2002	**0.012**	**1.550**	0.1
492695	SILVER CK @ CITY PARK AB PROSPECTOR SQUARE	2/14/2002	**0.012**	**1.460**	0.0
492695	SILVER CK @ CITY PARK AB PROSPECTOR SQUARE	2/18/2002	**0.001**	**0.432**	0.1
492695	SILVER CK @ CITY PARK AB PROSPECTOR SQUARE	2/21/2002			0.1
492695	SILVER CK @ CITY PARK AB PROSPECTOR SQUARE	2/25/2002	**0.002**	**0.600**	1.0
492695	SILVER CK @ CITY PARK AB PROSPECTOR SQUARE	3/6/2002	**0.002**	**0.496**	1.0
492695	SILVER CK @ CITY PARK AB PROSPECTOR SQUARE	3/21/2002	**0.003**	0.328	0.4
492695	SILVER CK @ CITY PARK AB PROSPECTOR SQUARE	4/11/2002	**0.012**	**1.450**	4.0
492695	SILVER CK @ CITY PARK AB PROSPECTOR SQUARE	5/16/2002	**0.003**	0.223	3.0
492695	SILVER CK @ CITY PARK AB PROSPECTOR SQUARE	6/6/2002			1.0
492695	SILVER CK @ CITY PARK AB PROSPECTOR SQUARE	6/27/2002			0.2
492697	PARK MEADOW DRAIN CK FROM GOLF COURSE AB SILVER CK	7/23/1998	0.000	0.042	12.0
492697	PARK MEADOW DRAIN CK FROM GOLF COURSE AB SILVER CK	8/27/1998			3.0
492697	PARK MEADOW DRAIN CK FROM GOLF COURSE AB SILVER CK	10/1/1998			2.5
492697	PARK MEADOW DRAIN CK FROM GOLF COURSE AB SILVER CK	10/29/1998	0.000	0.000	2.0
492697	PARK MEADOW DRAIN CK FROM GOLF COURSE AB SILVER CK	12/17/1998			2.4
492697	PARK MEADOW DRAIN CK FROM GOLF COURSE AB SILVER CK	1/21/1999	0.000	0.000	12.0
492697	PARK MEADOW DRAIN CK FROM GOLF COURSE AB SILVER CK	2/18/1999	0.000	0.120	0.4
492697	PARK MEADOW DRAIN CK FROM GOLF COURSE AB SILVER CK	3/26/1999			3.1

492697	PARK MEADOW DRAIN CK FROM GOLF COURSE AB SILVER CK	4/14/1999	0.000	0.046	2.5
492697	PARK MEADOW DRAIN CK FROM GOLF COURSE AB SILVER CK	4/29/1999	**0.001**	0.210	8.0
492697	PARK MEADOW DRAIN CK FROM GOLF COURSE AB SILVER CK	5/14/1999	0.000	0.050	10.0
492697	PARK MEADOW DRAIN CK FROM GOLF COURSE AB SILVER CK	6/3/1999			16.0
492697	PARK MEADOW DRAIN CK FROM GOLF COURSE AB SILVER CK	6/17/1999	0.000	0.031	6.0

Appendix B

Seasonality and Statistical Analysis of Uncertainty

Seasonality and Statistical Analysis of Uncertainty

Variability and Uncertainty

As discussed in the body of this report, the issue of statistical reliability of data analysis was addressed by clustering the individual data points in Bi-Monthly (seasonal) time periods. This allowed for analysis of seasonal patterns. On the average there are 5.5 data points per period for Cadmium and 5.6 data points per period for Zinc. These numbers provide reasonable statistical validity for the conclusions presented. Table 10 shows average statistical parameters for the two constituents.

Table 10: Average Statistical Parameters

Constituent	Coefficient of Variation	Coeff. of Variation of the Means
Cadmium	118%	50%
Zinc	82%	35%

The coefficients of variation above indicate that typical data points for cadmium and zinc are, on average, within 118% and 82%, respectively, of the mean value. However, there exists significant uncertainty as to the accuracy of the estimated means for these clusters. The coefficient of variation of the means represent how tightly clustered the mean values are (between stations) relative to the mean value.

Seasonality

The annual pattern of normalized zinc concentrations is shown in Figure 1. As indicated by the graphical representation of the normalized data, this annual pattern is consistent throughout the reaches of Silver Creek between Wanship and Park City. Concentrations increase sharply between the September-October period and the November-December period, even though flows do not yet show significant upswing. So it is not necessarily a feature of flow-induced scouring.

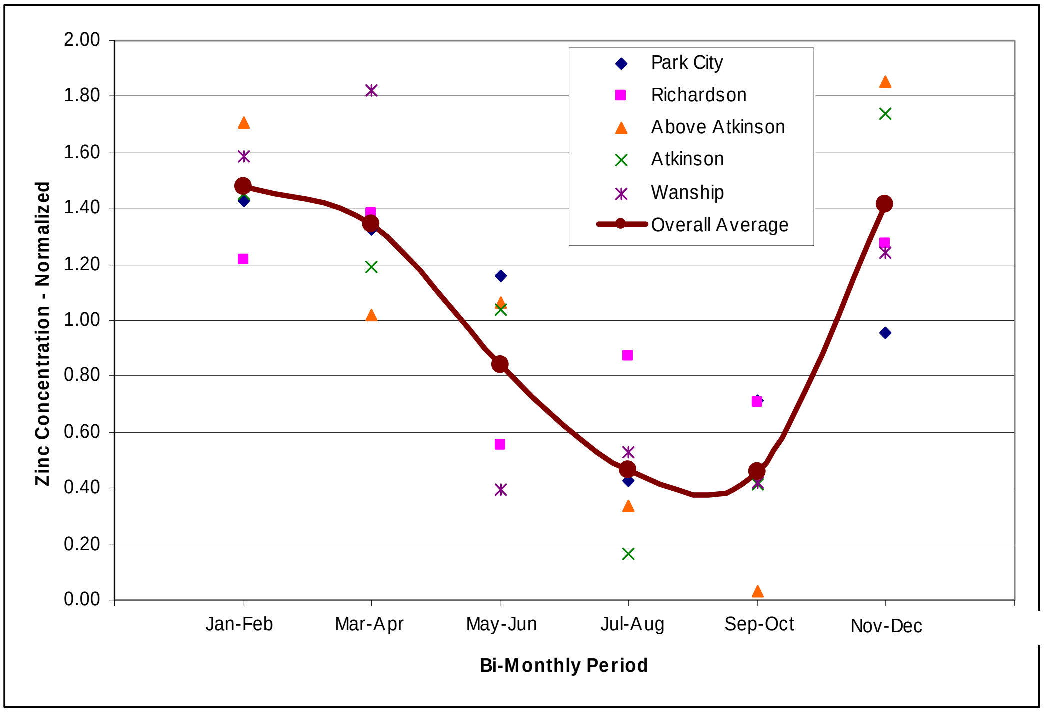

Figure 1: Annual Patterns of Zinc Concentrations

The annual pattern of normalized flows is shown in Figure 2. This pattern is characteristic of watersheds that are heavily influenced by snowmelt runoff. Note the peak flow period is May-June when concentrations have begun to decline.

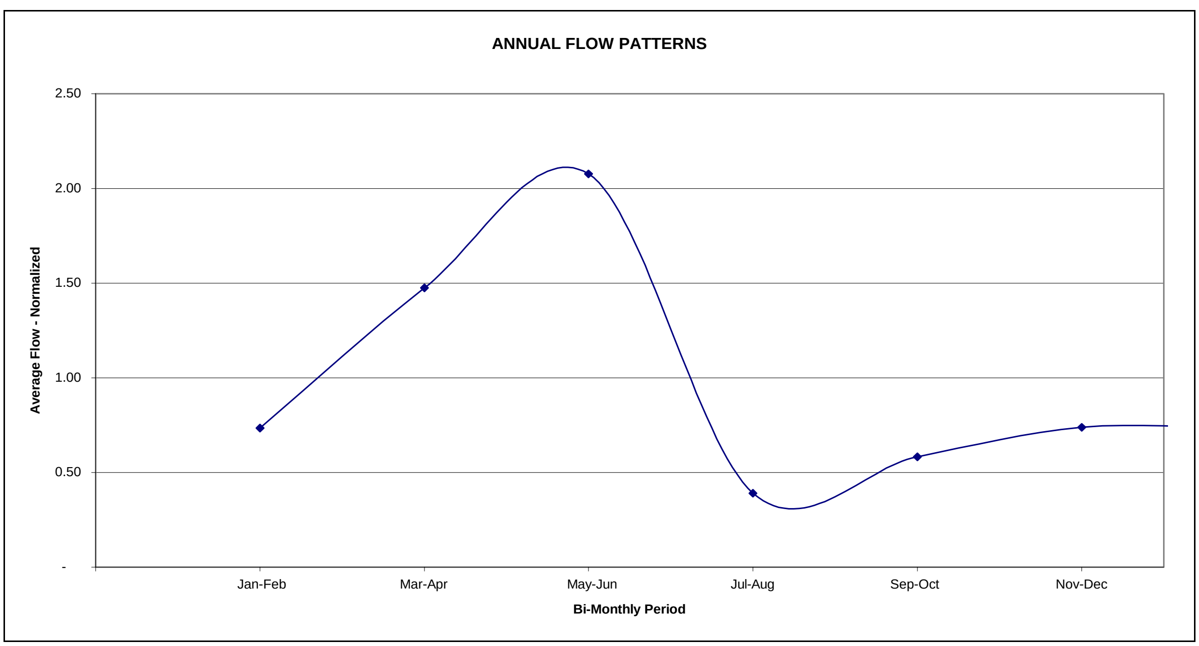

Figure 2: Annual Flow Patterns

Plotting Average Zinc Concentrations vs. Average Flow results in an Hysteresis Curve as shown in Figure 3. This plot shows values normalized by mean concentrations and flows. The mean values correspond to 1.0 on each axis. Values above or below 1.0 indicate values that are above or below the mean value. Early in the Winter season concentrations increase dramatically, even though flows have not yet begun to see the influence of significant snowmelt runoff. There are some possible explanations for this phenomenon, including the flushing of solubilized zinc from near-surface deposits at the onset of winter precipitation. However, the data are insufficient to verify this or other mechanisms.

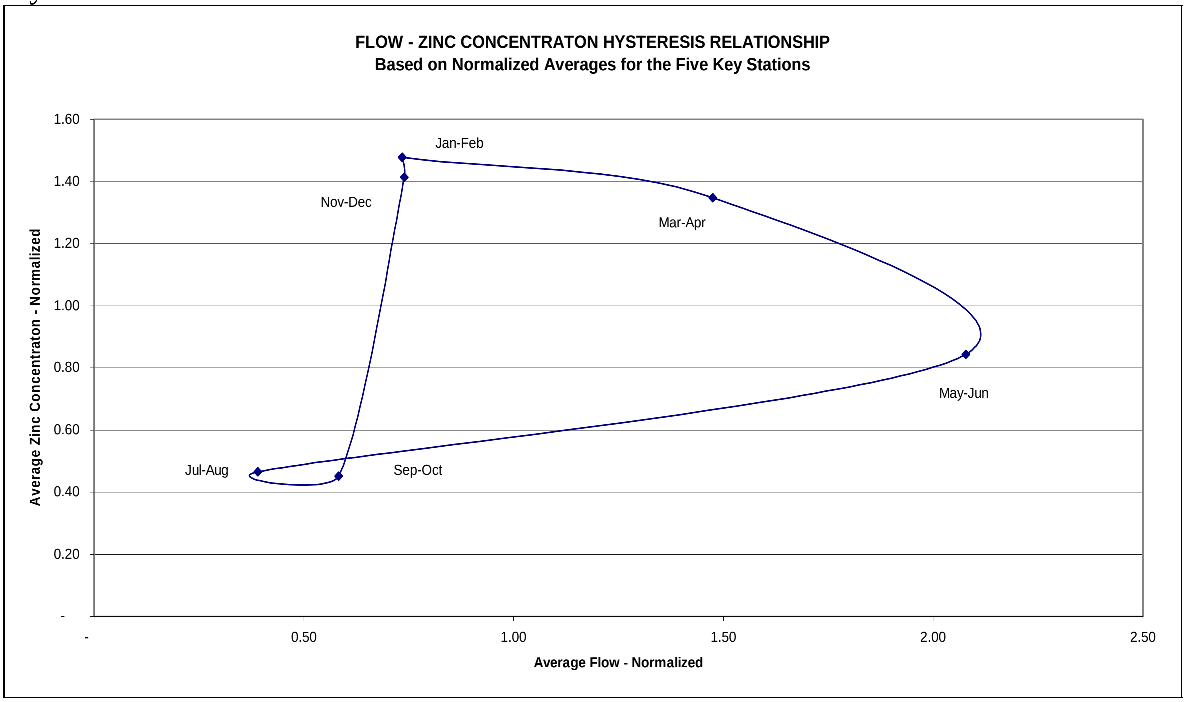

Figure 3: Flow - Zinc Concentration Hysteresis Relationship

The Annual Pattern of Zinc Loadings is more dramatic, as shown in Figure 4. The ratio of peak loadings in the Spring to minimum loadings in the Summer is about 8:1. This behavior could be incorporated in a comprehensive remediation strategy.

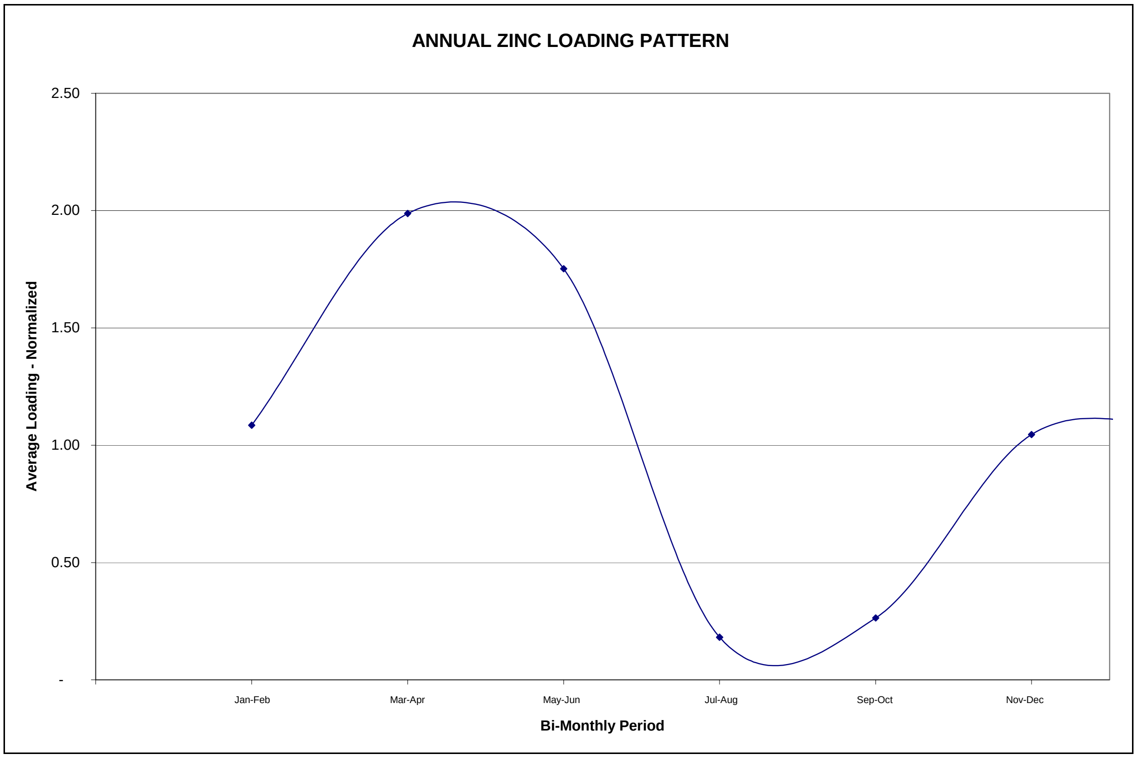

Figure 4: Annual Pattern of Zinc Loadings - based on Normalized Data

Hardness

Seasonal analysis of hardness data for each of the five key sampling locations indicates that there is significant variation by season at all stations except 492685 (Richardson Flat). Figure 5 shows a graphical representation of annual average hardness by station. Figure 6 depicts the seasonal variation using the bimonthly approach applied to other water quality data in this report.

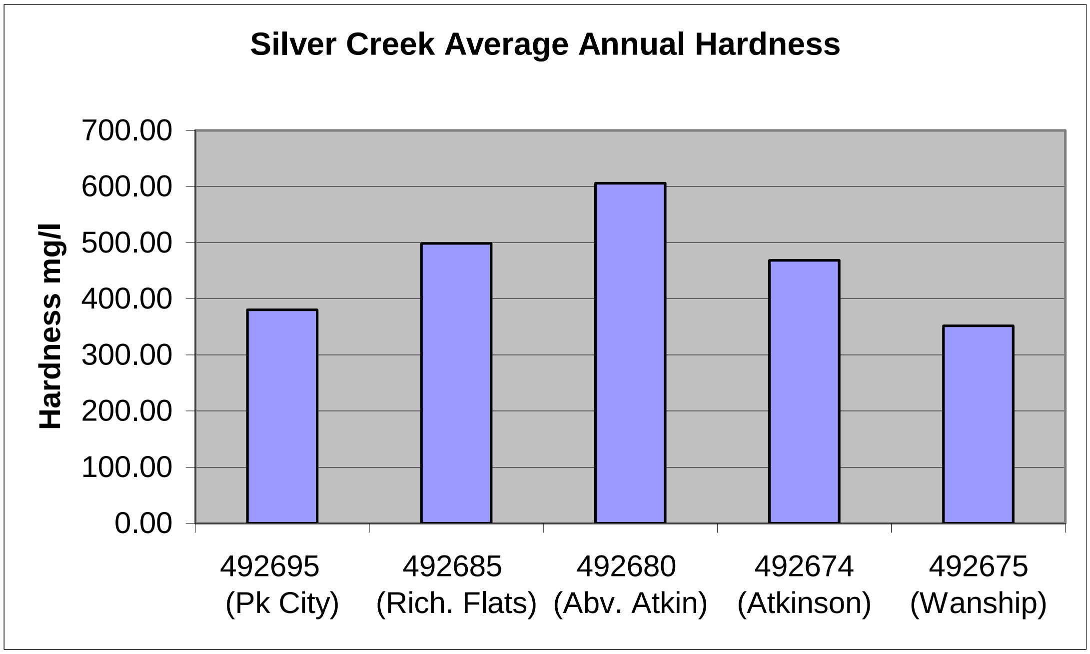

Figure 5: Average Hardness values

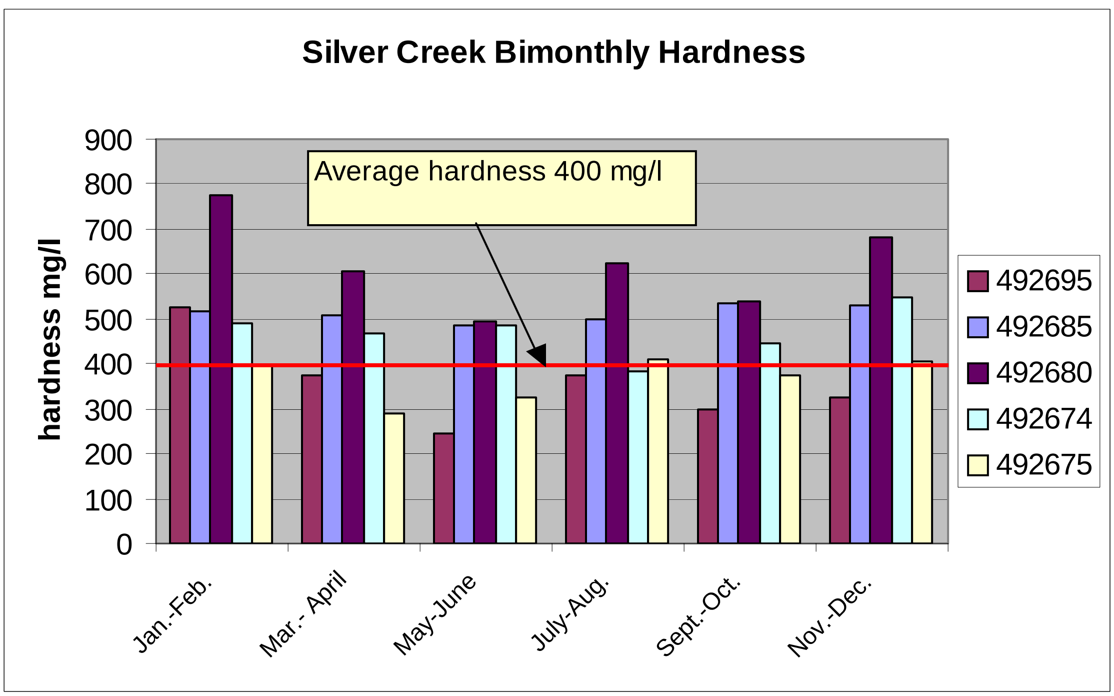

Figure 5: Bimonthly Hardness